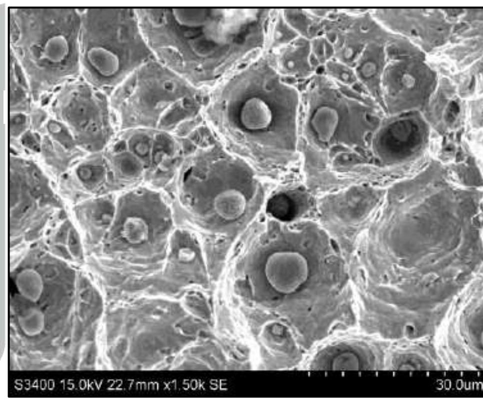
Journal of Materials, Manufacturing & Failure Analysis for Structural Integrity

SFA Mumbai Chapter



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PILLAI HOC COLLEGE OF ENGINEERING & TECHNOLOGY RASAYANI

News at a Glance

- From the editor's desk
- Journal Launched under the leadership of Dr. K. M. Vasudevan Pillai, Founder Chairman & CEO of MES & Dr.Daphne Pillai, Secretary MES

Dr. K. M. Vasudevan Pillai
Chairman & C. E. O
Mahatma Education Society

Dr. Daphne Pillai
Secretary
Mahatma Education Society

- Application of SEM to analyze failure of LM76 IC used for Ultrasonic Cleaner
- Fractography & Failure Analysis for Product and Process Development in Industries
- Events Forthcoming:
- International Olympiad in Hot Bulk Forging & Extrusion Technologies using QFORM Software
- Professional Training On Applications Of Electron Microscopes For Failure Modes And Effect Analysis Of Bearings And Brake Discs to Find Root Cause Of Failure & Its Mitigation
- Two Days Intensive Workshop On Fracture Mechanics & Failure Analysis: Research Opportunities to Solve Industrial Problems

From Editor's Desk

WELCOME TO THE THIRD ISSUE OF THE JOURNAL

The failure of structures and their degradation in service is of great concern to the Indian manufacturing industries. It affects all industries and results in loss of equipments , production loss, environmental pollution and even loss of life that involves costly litigation. The assessment of integrity of components in the presence of defects is becoming increasingly important for the safety as well as economic reasons. The cost of failure estimated by different agencies is around 3-4% of the GDP of a country. Most failures can be prevented if we adopt the available current technology, do R&D and take adequate precautions at the design, manufacturing and operating stages. India is one of the fastest growing economy in the world and needs to identify the root cause of failures in products and take preventive methods to mitigate them. Analysis of failure by industries can expand the knowledge of processing and product development. The purpose of starting this journal is to spread awareness of failure analysis in industries, educational and research organizations through R&D , design thinking and innovation to enhance the product quality and prevent future failures.

Aims & Scope of the Journal :

- Promote academic research and root cause analysis of industrial failures
- Cover failures related to all sectors of industries and all types of loading
- Create pool of manpower that is conversant with different analytical tools and techniques of materials characterization and failure modes and effects analysis
- Create ecosystem of failure analysis for innovation and entrepreneurship

The journal is an integral part of the Society for failure analysis Mumbai chapter. The quarterly open access journal intends to cover topics related to materials, manufacturing and failure analysis. We invite authors to contribute manuscripts of their papers. Submission implies that the work has not been published earlier, except in the form of abstracts , lectures, academic theses. It may be a research paper, review paper or a short communication. One of the authors may be designated as the corresponding author with his affiliation and email. Please use spell check and grammar check to avoid errors. The structure of article should consist of Abstract with key words, Introduction, Materials & Methods, Experimental, Results & Discussion followed by references. The style of reference should be as in any standard journal like the Journal of Engineering Failure Analysis published by Elsevier.

I extend hearty congratulations for your proactive support and contributions and best wishes for the new year. Let us resolve on the eve of new year to look failure analysis through the lens of research, innovation and entrepreneurship.

LET US LOOK FAILURE ANALYSIS THROUGH THE LENS OF RESEARCH,INNOVATION & ENTERPRENURESHIP

Application of SEM to analyze failure of LM76 IC used for Ultrasonic Cleaner

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Abstract

SEM is considered a valuable tool for analyzing the failure modes and mechanisms. The majority of the early work on Fractography was performed on metals. However it can be used for non-conducting materials after gold is sputtered on surface. In this paper, a premature failure of the pins of an LM76 integrated circuit (IC) that was mounted on a glass epoxy PCB has been investigated using Scanning Electron Microscope (SEM) and Energy Dispersive X-ray analysis (EDAX). It was used for sensing temperature in an ultrasonic cleaner. It sends the signal to control the system parameters. Reliability of such temperature sensors is very important since an inaccurate temperature measurement could lead to an inefficient system management that may even result in systemic failure. The reasons for premature failure have been attributed to poor fabrication, sharp bend design in the pins of the IC leading to residual stresses, improper cleaning of the flux (Mg), etc. The ways to prevent such failures in future is suggested.

Keywords: SEM, EDAX, LM76, ultrasonic cleaner, temperature sensor, failure analysis,.

Introduction

Failure analysis is a critical tool in the development of engineering processes and products. The LM76 is a digital temperature sensor with a Serial Bus interface used to measure temperature with an accuracy of ±1°C. The component consists of an integrated circuit (IC) mounted on a glass epoxy printed circuit board. A premature failure of the pins of the LM76 temperature sensor was reported that has been investigated using SEM to identify the failure modes and mechanisms .

Applications

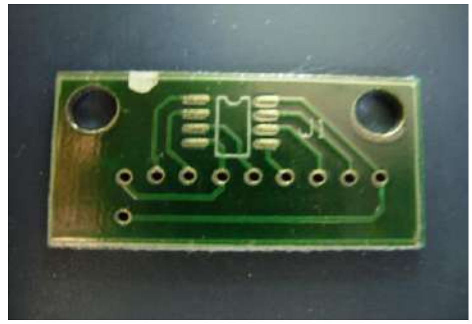
LM76 temperature sensors are extensively used for temperature sensing in personal computers, system thermal management, office electronics, ultrasonic cleaner, etc. The reliability studies of these components are very important to avoid systemic failure. The component under investigation is used as a temperature sensor for ultrasonic cleaner which vibrates with 20 kHz. It passes the information through a serial interface to the computer. The ideal operating environment temperature of the IC is 700°C.

Circumstances leading to failure

The component failed prematurely during service. The failure was predominantly observed in the IC pins, which had sharp bends.

Visual inspection of the failed component

Figure 1 shows the IC and the printed circuit board (PCB) before failure and Figure 2 shows them after failure as could be perceived by the naked eye.



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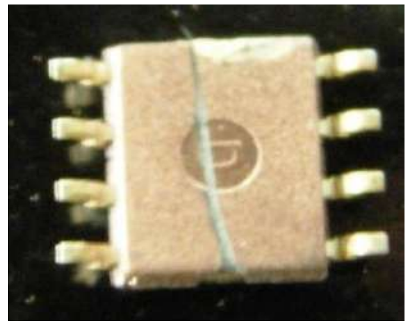

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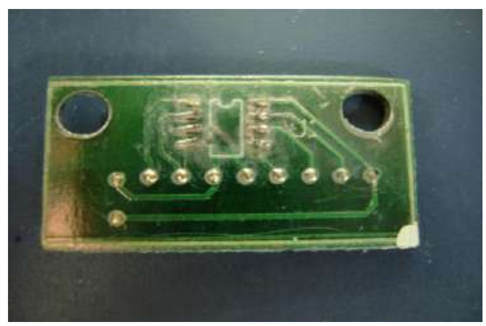
Fig. 1(a) PCB before failure (b) IC before failure



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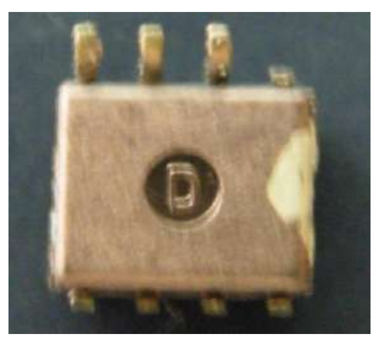
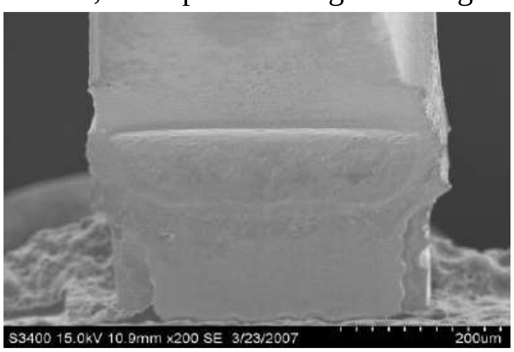


b.

Fig. 2 (a) PCB after failure (b) IC after failure

SEM and EDAX analysis

The SEM and EDAX of the failed regions of the IC were carried out after coating with gold. The images obtained during SEM are shown in Fig. 3 and Fig. 4. Fig.3 shows the pin of the IC which had a bend. The SEM images at lower magnification before and after failure are shown in Fig.3(a and b). However, fractographs of the fractured region shown in Fig.3b, at higher magnification shows presence of microcracks Fig.4a. Fig.4b shows the presence of white particles. Fig 5 shows the EDAX of the IC pin before failure. Here the higher amount of Si is observed as it is used in bond/connecting wires. EDAX analysis of white particles shown in Fig.4 b confirms that they contain Mg, Sn, Pb in substantial quantities, as depicted in Fig.6 and Fig.7.



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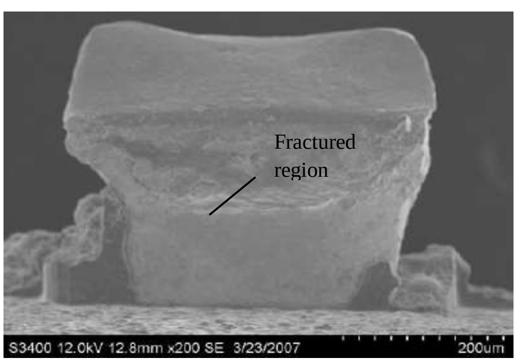
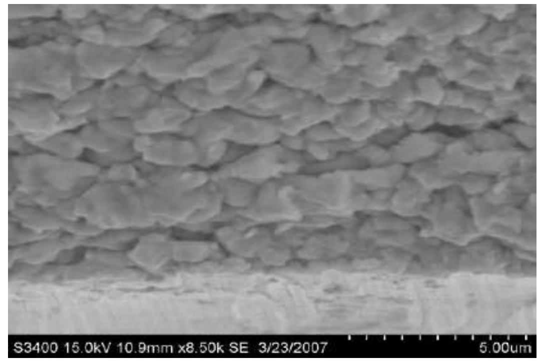


b.

Fig. 3 (a) shows the region of component before failure occurred. (b) Shows the same region after failure



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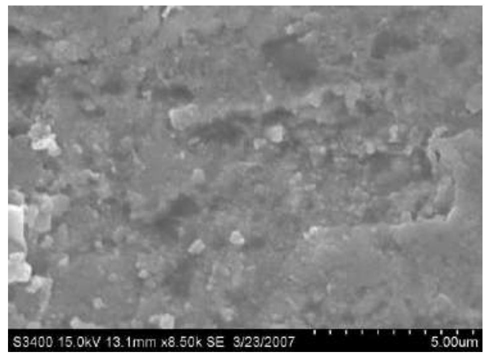
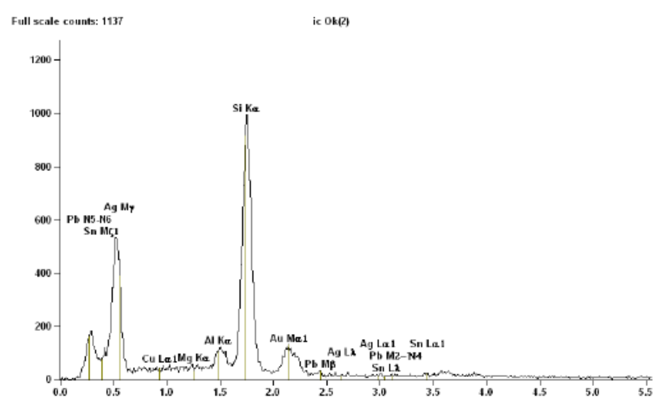
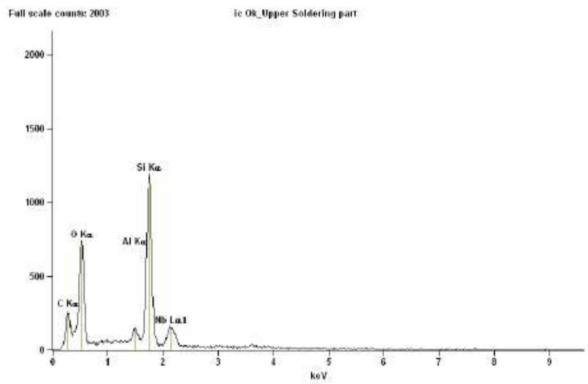


b.

Fig. 4 (a) Shows the bend region of the IC leg (interface between the soldered and the pure region can be seen) The pure region shows the presence of microcracks which may be one of the factors enhancing the failure. (b) shows the fracture region at a higher magnification. It shows the presence of white particles which on analysis by EDX confirms that they contain Mg, Sn, Pb in substantial quantities.



5(a)



5(b)

Fig. 5 (a) EDAX of the IC pin before failure in the region far away from bend of the pin
(b) EDAX of the IC pin before failure in the region of the bend of the pin

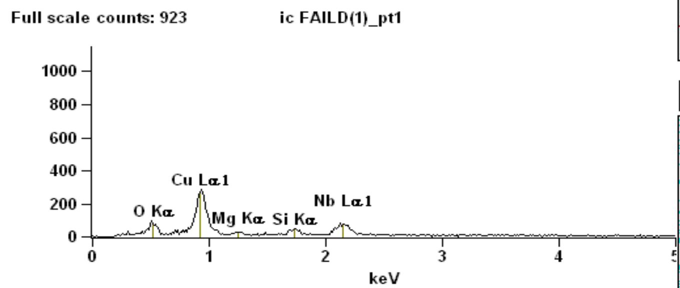
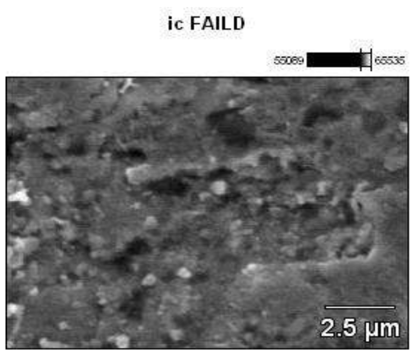


Fig. 6 EDAX of the IC pin after failure in the region of the bend of the pin

Data Type: Counts Mag: 9000 Acc. Voltage: 15.0 kV



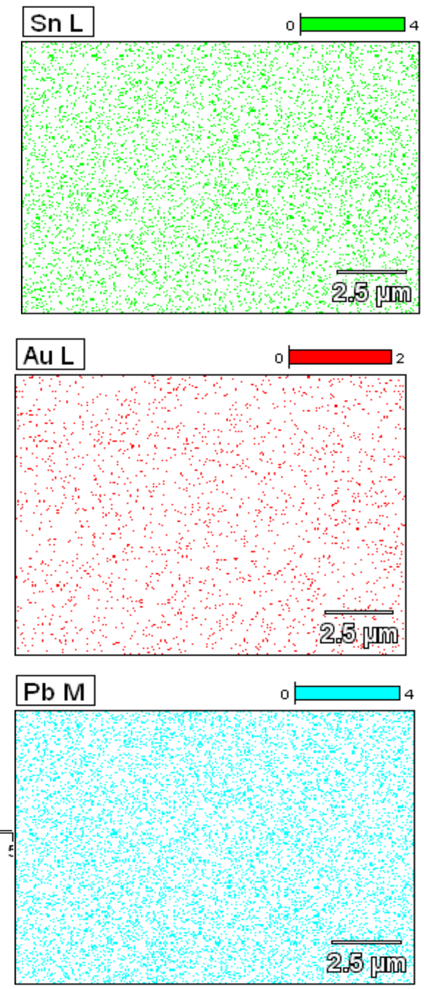


Fig. 7 EDAX elemental mapping of Sn, Au and Pb in the white particles observed in the failed sample.

Discussion / Probable cause

The SEM fractograph Fig. 3a shows the presence of microcracks in the region near the reflow soldering in the component which is not yet failed (just fabricated or unused component). This region also shows the presence of elements like Mg, Si, Al, and Nb. The region of failure is just adjacent to the bend joint in the leg of the IC pin, where reflow soldering is done. The region of failure shows brittle fracture. This region does not show the presence of Pb in the component which is not yet failed (just fabricated or unused component). However, the same region in a failed component shows the presence of substantial amount of Pb, which is used during reflow soldering, elsewhere. Mg is found in the bend region of the pin of the component which is not yet failed (just fabricated or unused component). Ideally, flux should have been removed before the actual IC is put into use. A strong possibility of migration of this Pb to the microcracks due to ultrasonic vibrations of the component is predicted and this is confirmed by SEM and EDAX of the failed region in the failed component. This appears to be only source from which Pb can come. The SEM shows the presence of white particles in the failed region. The EDAX of these particles confirm that these contain Mg and Pb. A possibility of leaching of Mg by Pb in this region is also suspected which can lead to substantial crack growth rates. Another possible cause of failure is propagation and growth of the microcracks present in the region next to reflow soldered region in the IC leg by various mechanisms. These cracks grow due to cyclic loading (fatigue) caused by ultrasonic vibrations and also the migration and penetration of Pb in this area. Also the resistive heating of the pin provides the activation energy needed for the intermetallic formation. As the crack grows the resistive heating increases due to the decrease in the cross section area through which the current flows, as the original region where the current could flow earlier is now occupied by empty spaces (cracks). At intermetallic thicknesses greater than 20 μm, brittle fracture between Cu_6Sn_5 and Cu_3Sn are reported to be the most common failure mechanism [1]. The component that we investigated shows the presence of substaintial amount of Cu and Sn and the failure in this region is also brittle. In such systems Au is found to cause embrittlement failure by forming $AuSn_4$, as is reported by others [2]. However, this does not apply to our investigation as the presence of Au is negligible in the failed region.

Conclusion / Remedial methods

The microcracks present due to faulty fabrication parameters grow and cause destructive failure of the pins. Also the cyclic fatigue loading experienced by the pins due to high frequency ultrasonic vibrations of the IC results in faster crack propagation if the pins are too stiff. Migration of Pb from the reflow soldered area can contribute to enhanced crack growth rates. Another possible cause of failure is the sharp bend of the pins connecting IC to the PCB. This may result in high residual stresses when the pins are bent to the desired shape during manufacturing. This is a result of improper design. The possible solution to avoid premature failure may consists of through cleanup of Mg from the region of crack formation after reflow soldering. Also proper care must be taken after soldering to avoid microcrack formation during cooling. Lead free soldering techniques like polyphthalamide (PPA) based soldering [3] and others described by Falinski, W.; Koziol, G.; Hackiewicz, H.; Sitek, J.[4] may be tried out for mass lead free reflow soldering .

Acknowledgement: The authors would like to acknowledge the support from Roop Telsonic Ultrasonix Limited, Mumbai

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Fractography & Failure Analysis for Product and Process Development in Industries

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Introduction

Fractography

Fractography is the study of fracture surfaces in order to determine the relation between the microstructure and the mechanisms of crack initiation, propagation and, eventually, the root cause of the fracture.

Fractography involves gathering background information about design, materials selection, processing & assembly. The knowledge of material science and fracture mechanics is needed for the Failure Modes & Effects Analysis (Fishbone analysis). ASTM standard 1322 describes it "as a means and methods of characterizing fractured specimens or coupons". It is considered a valuable tool for analyzing failures of engineering components that eat 4% of the GDP of a developing country. Flaw type and its location are as important as stress conditions (Plane stress/Plane strain) that are responsible for the mechanisms of the fracture. It has to be borne in mind that cracks propagate in response to stresses and strains and therefore fractography comes as a natural corollary to scientists and engineers.

The majority of the early work on fractography in the mid-twentieth century was performed on metals, ceramics, and glass materials. The widespread use of fractography in analyzing plastics ,rubbers & their composites began decades later, as their use in load bearing applications and the frequency of associated failures increased.. In many cases, fractography requires examination at a finer scale, which is usually carried out in a SEM that has resolution much higher than the optical microscope. As most plastics, rubbers & their composites are not conductors the electrons charging in SEM may result in local melting. To avoid this either gold is sputtered on surface or when coating is not possible ESEM specimen chamber is filled with high pressure gaseous environment are used.

Advantages of SEM[1]

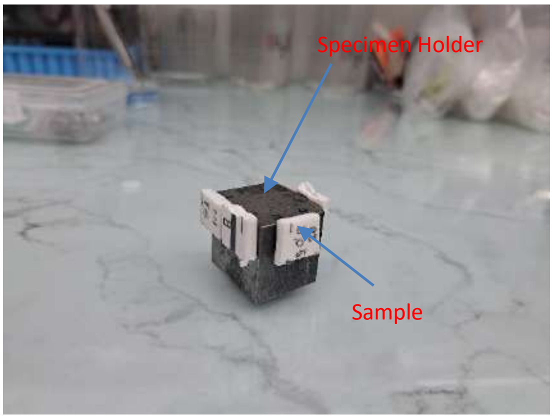
The scanning electron microscope has many advantages over traditional microscopes.

1. The SEM has a large depth of field, which allows different levels of a specimen to be in focus at one time.
2. The SEM also has much higher resolution, so closely spaced objects can be identified & magnified at much higher levels.
3. Since the SEM uses electromagnets rather than optical lenses, the researchers has much more control in the degree of magnification.

All of these advantages, as well as the actual strikingly clear images, make the scanning electron microscope one of the most useful instruments in research today.

Sample Preparation

SEM samples have to be small enough to fit on the specimen stage, and may need special preparation to increase their electrical conductivity and to stabilize them, so that they can withstand the high vacuum conditions and the high energy beam of electrons.[2] Samples are generally mounted rigidly on a specimen holder or stub using a conductive adhesive as shown in image below.

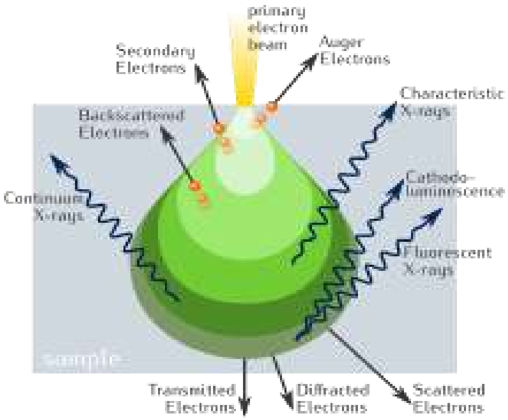


For conventional imaging in the SEM, specimens must be electrically conductive, at least at the surface, and electrically grounded to prevent the accumulation of electrostatic charge. Metal objects require little special preparation for SEM except for cleaning and conductively mounting to a specimen stub. Non-conducting materials are usually coated with an ultrathin coating of electrically conducting material, deposited on the sample either by low-vacuum sputter coating or by high-vacuum evaporation. Conductive materials in current use for specimen coating include gold, gold/palladium alloy, platinum, iridium, tungsten, chromium, osmium,and graphite[3].

Nonconducting specimens may be imaged without coating using an environmental SEM (ESEM) .

How it works

The signals used by a SEM to produce an image result from interactions of the electron beam with atoms at various depths within the sample. Various types of signals are produced including secondary electrons (SE), reflected or back-scattered electrons (BSE), characteristic X-rays and light (cathodoluminescence) (CL), absorbed current (specimen current) and transmitted electrons as shown in figure below. The secondary electrons reveal surface topography, backscattered electrons give a combination of topography, atomic number & crystallographic information. X-rays reveals compositional information. The electron beam interacts with the specimen surface and signals come from different depths of material shown below.[2]



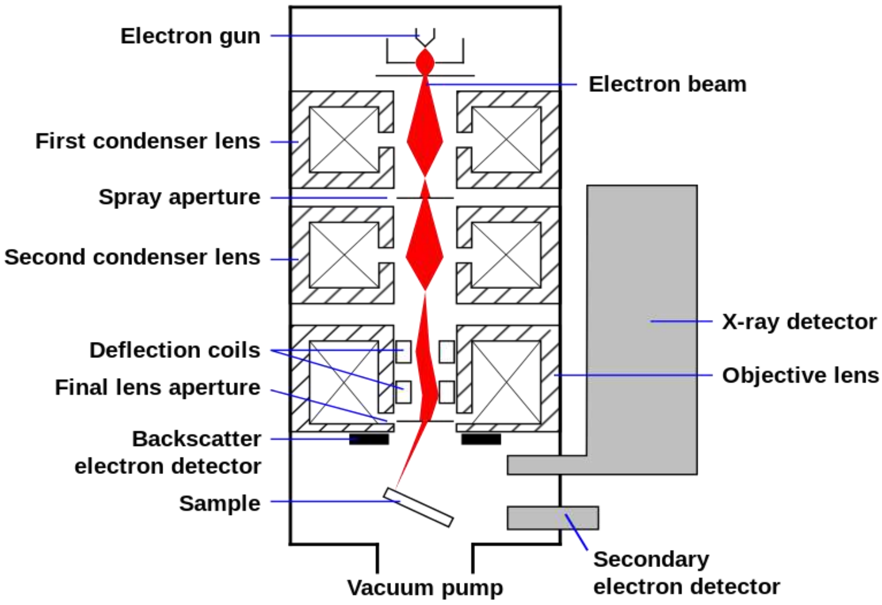
Electron–matter interaction volume and types of signal generated[2]

Secondary electrons are low energy electrons (10eV-50eV) primarily produced from material close to surface. This limits their mean free path in solid matter. Consequently, SEs can only escape from the top few nanometers of the surface of a sample. The signal from secondary electrons tends to be highly localized at the point of impact of the primary electron beam, making it possible to collect images of the sample surface with a resolution of below 1 nm.

Back-scattered electrons (BSE) are higher energy electrons (5KeV-40KeV), up to energy of incident beam and are emitted from larger volumes than secondary electrons. Here electrons are reflected from the sample by elastic scattering. Since they have much higher energy than SEs, they emerge from deeper locations within the specimen. They give both topographical and compositional responses. It detects phase distribution in heterogeneous or composite microstructures, inclusions and second phase concentrations. Such information misses completely in secondary electron imaging. However, the resolution of BSE images is less than SE images, BSE are often used in analytical SEM along with the spectra made from the characteristic X-rays, because the intensity of the BSE signal is strongly related to the atomic number (Z) of the specimen. BSE images can provide information about the distribution, but not the identity, of different elements in the sample.

Due to the very narrow electron beam, SEM micrographs have a large depth of field yielding a characteristic three-dimensional appearance useful for understanding the surface structure of a sample.[4]

Schematic of an SEM



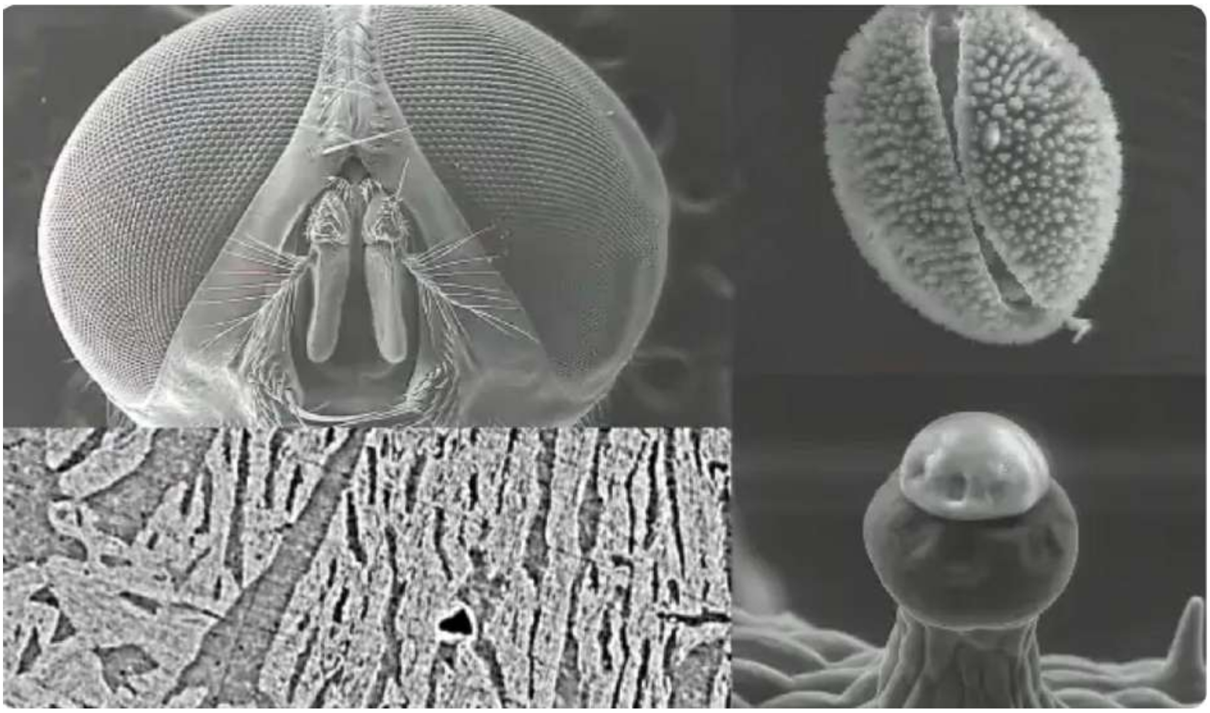
In a typical SEM, an electron beam is thermionically emitted from an electron gun fitted with a tungsten filament cathode. Tungsten is normally used in thermionic electron guns because it has the highest melting point and lowest vapor pressure of all metals.

The electron beam, which typically has an energy ranging from 0.2 keV to 40 keV, is focused by one or two condenser lenses to a spot about 0.4 nm to 5 nm in diameter. The beam passes through pairs of scanning coils or pairs of deflector plates in the electron column, typically in the final lens, which deflect the beam in the x and y axes so that it scans in a raster fashion over a rectangular area of the sample surface.

Before examination the specimens are cleaned of greases, dust and debris. Specimen is soaked in acetone filled beaker that is ultrasonically agitated. For good contact of specimen with stub, they are fixed to stub by silver paint or by conductive carbon double sided sticky tape. A coating of 5nm to 40nm conductive gold / carbon is given by sputter coater. Coating is necessary to eliminate surface charge build up from electron bombardment it is not needed for conductive materials or at low accelerating voltages (1KeV – 5KeV) but low voltage has less resolution. Coating are not required on SEMs that operate at low voltages and low vacuums like Environmental SEMs.

Environmental SEM

Conventional SEM requires samples to be imaged under high vacuum, because a gas atmosphere rapidly spreads and attenuates electron beams. As a consequence, samples that produce a significant amount of vapour, e.g. wet biological samples or oil-bearing rock, they must be either dried or cryogenically frozen. ESEM is designed to operate both at high or low vacuum unlike conventional SEM that requires high vacuum. It can operate with environments having water vapor or other gases. Here specimen coating is not needed because static charges don't develop on a specimen since gases ionize and neutralize excess electron charge build up on the specimen. In environmental SEM (ESEM), the chamber is evacuated of air, but water vapor is retained near its saturation pressure, and the residual pressure remains relatively high. This allows the analysis of samples containing water or other volatile substances. With ESEM, observations of living insects have been possible.[6]

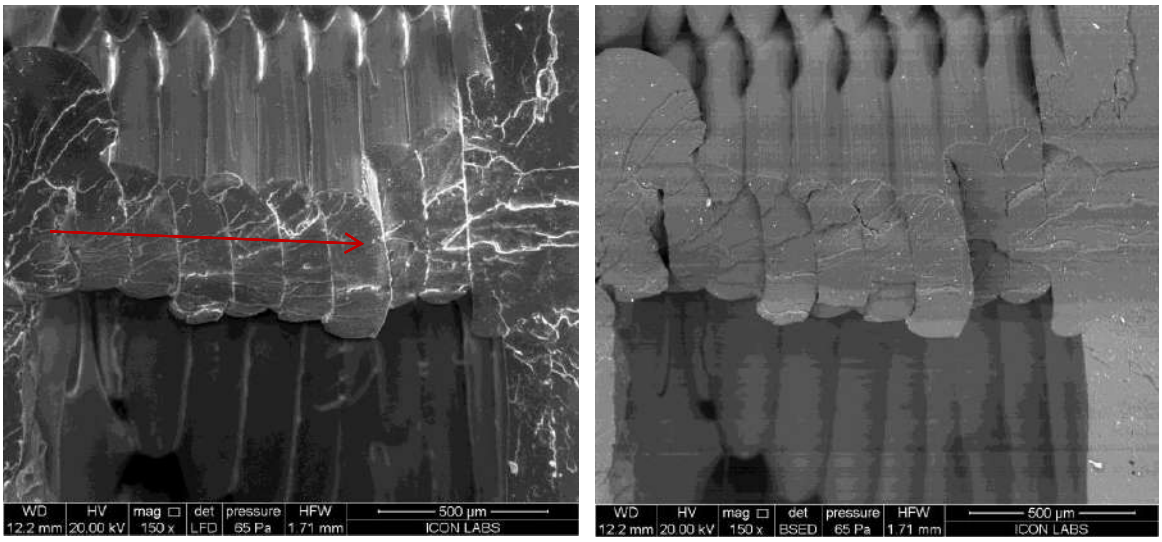


ESEM is especially useful for non-metallic and biological materials because coating with carbon or gold is unnecessary. Uncoated plastics and elastomers can be routinely examined, as can uncoated biological samples. X-ray analysis is difficult with a coating of a heavy metal, so carbon coatings are routinely used in conventional SEMs, but ESEM makes it possible to perform X-ray microanalysis on uncoated non-conductive specimens. The fractograph of an ant viewed in normal dissecting Microscope shows lack of resolution as well as depth of focus. However, the fractograph of a mite viewed in an ESEM reveals greater structural details and enhanced depth of focus.

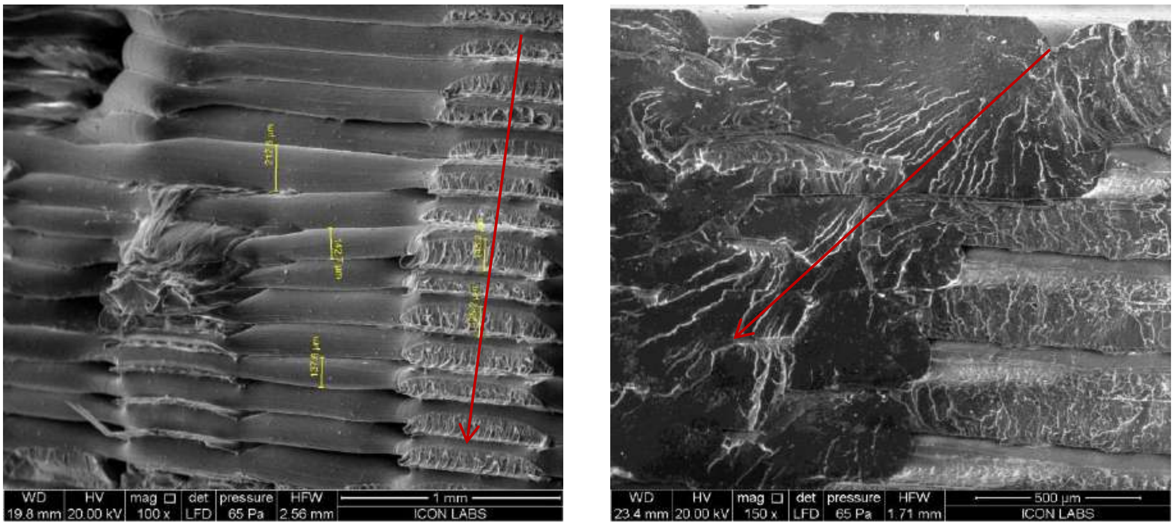
The ants head viewed in a normal dissecting Microscope shows lack of resolution as well as depth of focus

A mite viewed in an Electron Microscope reveals greater structural details and enhanced depth of focus

Fractography of 3D Printed Thermoplastics



The figure above shows the secondary and backscattered images of the tensile fractured 3D printed PLA. The crack initiation and its propagation through the deposited layers can be clearly seen. Since the infill density was only 20% therefore large voids in rasters at different levels are clearly visible in the environmental SEM.

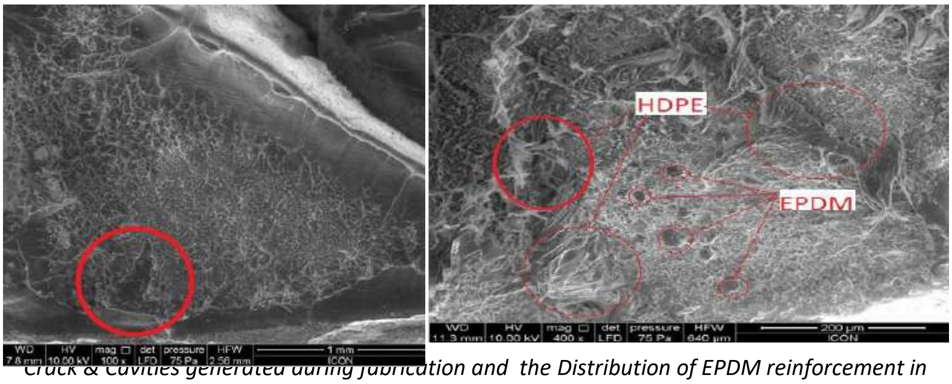


The fractographs shown above were taken from the fractured surface of compact tension specimen after fracture toughness test using ESEM. It clearly shows crack initiation and its propagation along with layered deposition during 3D printing at different levels

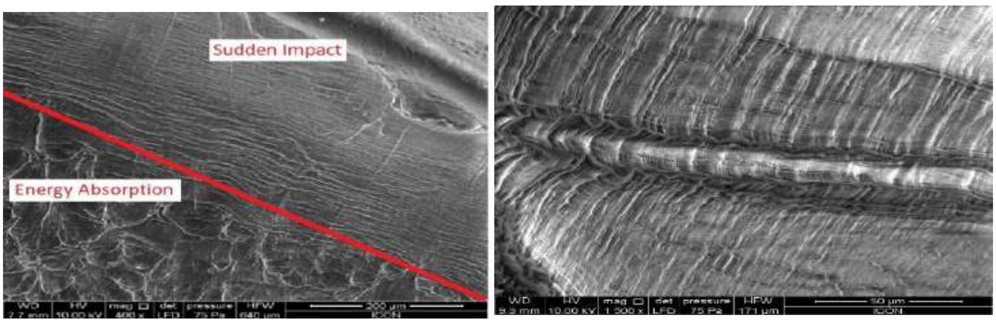
Fractography of EPDM synthetic rubber reinforced in the HDPE matrix

The fracture characteristics of a biodegradable viscoelastic ultra-high molecular weight Ethylene Propylene Diene monomer (EPDM), a synthetic rubber that was blended with a recyclable high density polyethylene (HDPE) thermoplastic in bra bender and two high mill and compression moulded was examined using the ESEM. The tensile Fractographs observed in ESEM are typical of two dissimilar polymers containing fillers that influence movement of viscous elastic polymer in highly crystalline linear molecular HDPE. The fracture located near notch tip consists of crack initiation and propagation. High speed and triaxial stress at the notch tip show deformation bands that look like crazes in the form of river lines. At lower fracture speed the fracture morphology changes to dimples aligned in the crack propagation direction.

An Environmental Scanning Electron Microscope (ESEM) was used to analyze the reinforcement particle size & fracture behavior of composites.



Crack & Cavities generated during fabrication and the Distribution of EPDM reinforcement in HDPE matrix of the composite are clearly seen in fractographs scanned in the ESEM



A collated view of Impact fracture showing crack initiation & energy absorption during propagation of the crack in the EPDM reinforced HDPE composite

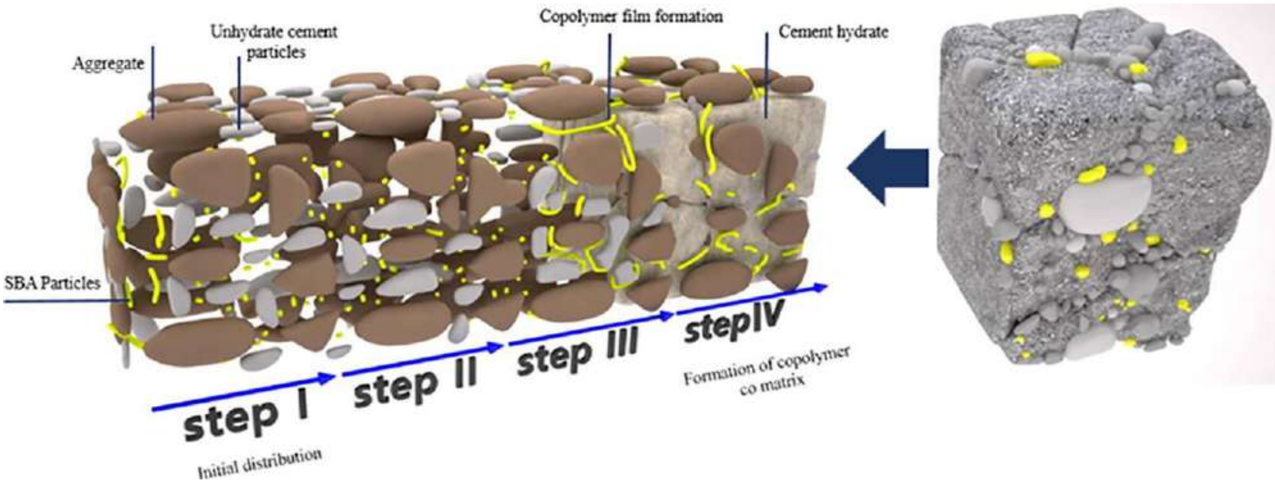
From the ESEM Fractography it can be inferred that to minimize the cavities & enhance mechanical properties of the composite mixture, the two-roll mill mixing process should be done properly, with the help of hot rollers.

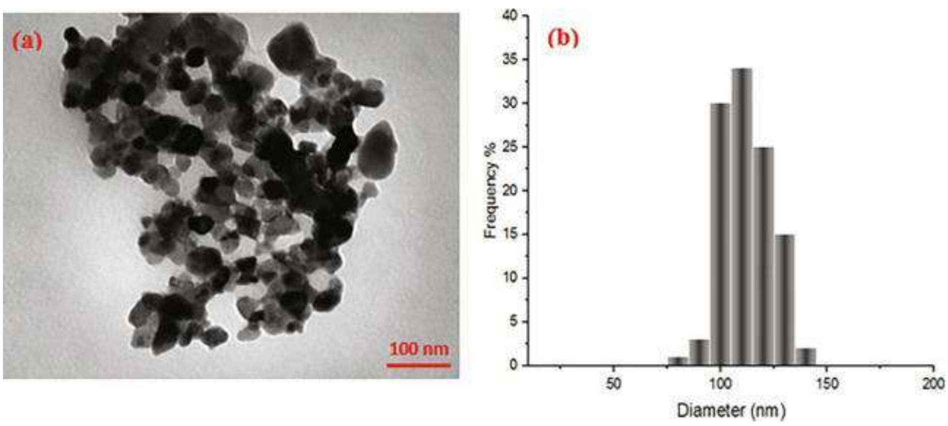
SEM of Polymers and Organic admixtures on portland cement hydration

Introduction

Cement-based materials have now become the dominant construction materials for the civil infrastructure all over the world. The addition of polymer to a cement mix can significantly enhance the properties of the resulting material, which is known as a polymer modified cement-based material.[8] Due to the rising importance of polymer modified cement- based materials in civil construction, many attempts have been made to clarify the mechanism of polymer modification.[9-12] Among these researches, Ohama's three-step model is taken as the most representative achievement in describing the forming process of polymer–cement co-matrix.[13]

Based on Ohama's model, some adjustments and refinements, in mechanical and durability performance evaluation of crumb rubber-modified epoxy polymer concrete overlays have been investigated. Super Plasitisizers and crystalline admixtures are added to Portland cement 1.2 % and 0.8% of cementieus material. The impact of various water-cement and superplasticizer-cement ratios on the mechanism of copolymer latex modified concrete such as mechanical strengths including compressive, flexural, and tensile, and microstructure formation aspects has been studied by researchers using FESEM, EDX, FTIR, and XRD tests to discuss SBA modified concrete's microstructure and properties. The interaction between nanoparticles of Styrene-Butyl Acrylate latex and cement particles with various water-cement and superplasticizers-cement ratios during the hydration process has been investigated to achieve the best chemical combination of the materials for enhancing the mechanical properties and workability of the concrete.[14]





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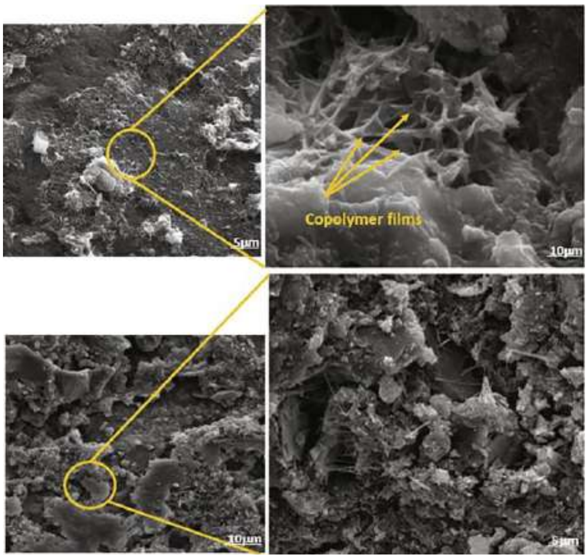
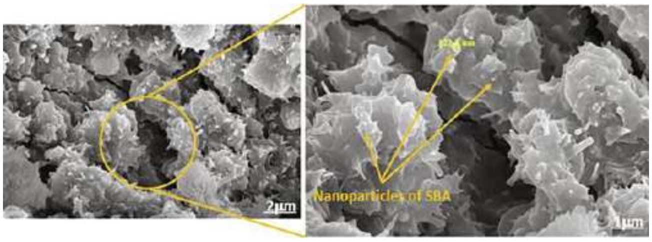
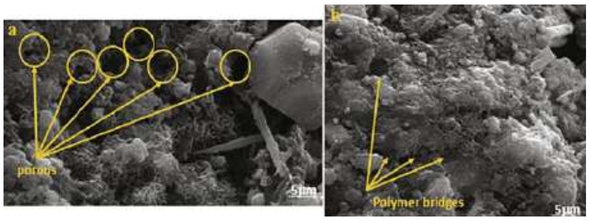
TEM micrographs nanocomposite of the SBA Size distribution (b) polydispersity index of SBA latex from DLS[14]



Microstructures of Polymeric films between layered calcium hydroxide crystals on the surface of concrete containing 3% of SBA and 1% superplasticizers (w/c ratio is 0.4). [14]



Distribution of the SBA nanoparticles among cement paste. [14]



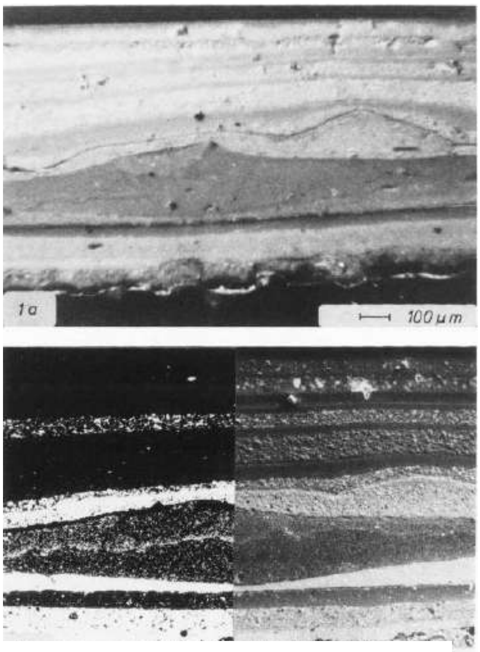
Comparison of the porous microstructure of (a) control concrete (b) modified concrete by 3% SBA and 1% superplasticizers. [14]

Conclusion:

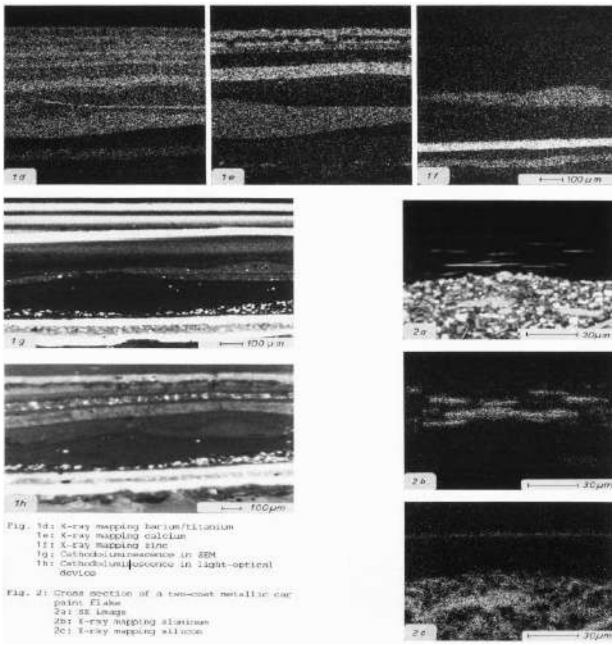
Decreasing the W/C ratio from 0.55 to 0.40 is reported to increase the mechanical properties of SBA modified concrete because nanoparticles of SBA latex are distributed better on the cement particle's surfaces due to the high amount of cement particles and superplasticizers. The most significant improvement of the compressive strength was found for the composites, including 0.40 water-cement ratio and 1% superplasticizer-cement ratio with 3% of SBA, rising almost 18% compared to the control sample. A much higher flexural strength was measured when 5% of SBA was added to the water-cement ratio of 0.4, with enhancing values of approximately 44%.

CHARACTERIZATION OF PAINTS

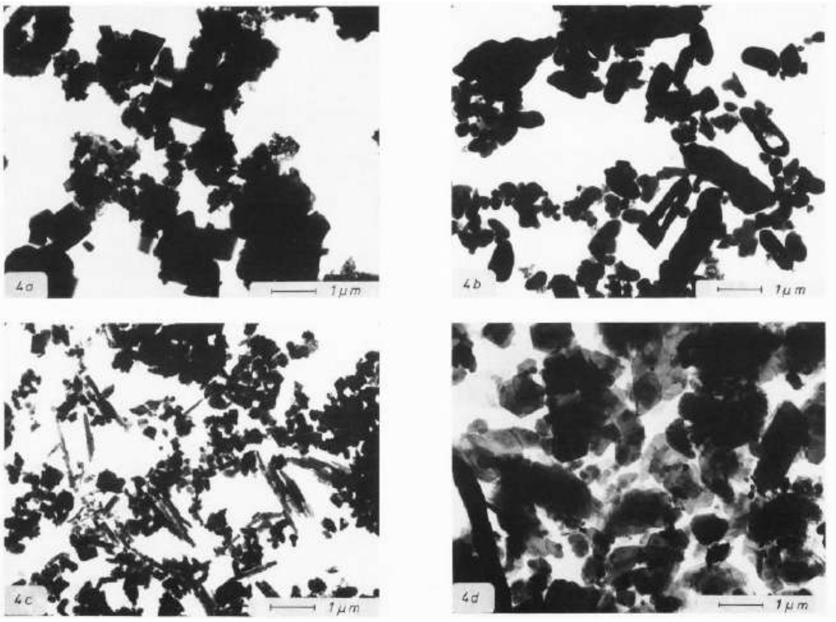
Objects are coated with paints that consist of binders, pigments, solvents & additives SEM & TEMs are used to evaluate micromorphology and chemical composition pigment particles. Layers of paints are better visible in SEM compared to LOM. BSE image provides information about composition and serves as a basis for elemental analysis (EDX). This can avoid time consuming X-ray mapping that is necessary for in homogeneously structured layers. In paints luminescence features of each component needs to be tested in addition to chemical analysis.



Cross section of a fragment of paint
a: Light-optical micr oscope
b: BSE image in SEM



TEMs are used to analyse pigments in primers for grain size and identifying the primers and fillers. [15]



Transmission electron microscopic of 4 different primers 4a: Opel 4b: Audi 4c: Karmann 4d: Mercedes images[15]

Application of TEM is of a special interest to the field of new pearl lustre pigment. TEM samples are prepared from small particle of paint that is dispersed in water and ultrasonically vibrated. The sediments are collected on the specimen grid and examined under TEM. The TEM micrographs show avoid variety of grain structure that is characteristics of manufacturers (primers of four manufacturers are shown in figure above). The elemental composition of each particle can be identified by EDAX i.e. $CacO_3$ in a / irregular shaped particles and elongated open particle b (Audi) consists of $BaSO_4$. TEM is also used for pearl lusture pigments used in USA for car coating. Pearl lusture pigments consist of thin layers of highly transparent metal oxides with high refractive indices (Titanium oxide on substrate of low refractive mica). Also a combination of thin layers of absorbing oxides like Fe_2O_3 or Cr_2O_3 is possible. Colour depends on the thickness of the layer(100-500nm) or on the combination of several layers. The intensity of pearl effect is altered by varying diameter of substrate particles (5-150µm).

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Activities Proposed

PHCET

QFORM

MAHATMA EDUCATION SOCIETY'S
PILLAI HOC COLLEGE OF ENGINEERING & TECHNOLOGY

ORGANIZES

INTERNATIONAL STUDENTS OLYMPIAD

ON

HOT BULK FORGING AND EXTRUSION TECHNOLOGIES USING QFORM SOFTWARE

Date: Feb./ March 2023

International Students Olympiad in Hot Bulk Forging and Extrusion Technologies 2023

Students of mechanical engineering are invited to take part in the International Students Olympiad in Hot Bulk Forging Technologies, which will take place in April 2023 at universities around the world.

The competition between students will consist of the following parts: students will get a drawing of an axisymmetric part after machining and should design the hot forged part and die impression for the final forging and then determine necessary technological chain for its manufacturing and then simulate proposed forging process. Students can choose an alternative task for developing technological process of hollow aluminium profile extrusion. Simulation will be performed in QForm software for estimation and verification of the developed technology.

Organizers are asked to submit a competition entry with a list of applicant students. If the local organizer invites students from multiple universities then each university is limited to 3 participating students so if more are interested in participating, then each university must pre-select 3 most qualified participants. If only one university is involved with a local organizer, then more than 3 students may participate. On the day of the event in April 2023 competing students should arrive to assigned class room and each student will work on a personal computer with QForm simulation and CAD software installed and will have 6 hours to design the technology, to simulate it and to create a report using text editor such as Microsoft Word. Students' reports should include calculations and justification of the proposed technology, applications and drawings in text file as well as saved QForm FE-simulation file. Each report will have special random number to achieve fair and unbiased judging. The results will be judged by a local committee. Winners will get diplomas and prizes. Then 1st place winners from each country will move on to the Scientific Committee judgment between countries where three best students' reports from around the world will get special diplomas and prizes.

Designed technology will be judged by the following criteria:

- computation of hot forged part drawing;
- justification of designed bulk forging technology;
- effectiveness and efficiency of proposed technology based on the results of simulation in QForm. Optimally designed technology should provide no defects, complete filling of the die impression, consist of minimum number of technological chain steps with high forging energy efficiency and high material consumption efficiency with optimal grain flow.

Basic language of the Olympiad is English. Each Organizer may use different languages for reports but the students' reports for International Committee judgment have to be translated into English.

Deadlines:

- January 2023: Organizational Committee membership confirmation (including contact person) to market@qform3d.com
- January 2023: Competition entry from universities (including request for QForm license if needed)
- March 2023: List with applicant students
- April 2023: Recommended date of the Olympiad at universities

Additional conditions:

All universities taking part in the Olympiad will get a free 3-month network QForm software license for 3 places to practice before the Olympiad by request. The universities will also get the solved example from the previous Olympiad for review as well as a training course of simulation in QForm.

Several participants of the past years:

IFU

AGH

b-tu

Coordinator

Micas Simulations Ltd., QForm Group
www.qform3d.com
market@qform3d.com

QFORM

Scientific Committee 2022

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Bauman MSTU (Russia),
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Dr. R. C. Prasad, Professor Department of Mechanical Engineering

Hebei University of Science and Technology (China),
Materials Science and Engineering Department
www.english.hebust.edu.cn
Professor Shibo Ma

Activities Proposed

PROFESSIONAL TRAINING

On

APPLICATIONS OF ELECTRON MICROSCOPES FOR FAILURE MODES AND EFFECT ANALYSIS OF BEARINGS AND BRAKE DISCS TO FIND ROOT CAUSE OF FAILURE & ITS MITIGATION

Fractography is not taught in the course curriculum of colleges and higher engineering institutes. As a result of this engineers and scientists don't become familiar to the fascinating subject of Fractography. It involves gathering background information about design, materials selection, processing & assembly. The knowledge of material science and fracture mechanics is needed for the Failure Modes & Effects Analysis (Fishbone analysis). ASTM standard 1322 describes it "as a means and methods of characterising fractured specimens or coupons". It is considered a valuable tool for analysing failures of engineering components that eat 4% of the GDP of a developing country. Everyday millions of components in different sectors of industries fail, but only a fraction of it is analysed fractographically to find the root cause and failure modes and effect analysis that are commonly referred to as Fish Bone Analysis.

Flaw type and damage mechanisms are as important as stress conditions (Plane stress/Plane strain) that are responsible for the mechanisms of the fracture. It has to be borne in mind that cracks propagate in response to stresses and strains and therefore fractography comes as a natural corollary to scientists and engineers. With a little practice engineers and scientists can be trained to analyse and interpret fractures of ductile and brittle materials.

In many cases, fractography requires examination at a finer scale, which is usually carried out in a SEM that has resolution much higher than the optical microscope. Conventional SEM requires samples to be imaged under vacuum, because a gas atmosphere rapidly spreads and attenuates electron beams. Due to the very narrow electron beam, SEM micrographs have a large depth of field yielding a characteristic three-dimensional appearance useful for understanding the surface structure of a sample.

This one day hands-on Professional Training programme is designed to understand micromechanisms of fracture due to overload, fatigue, wear & corrosion in bearings & braking system in automotives using electron microscopes. The Objective is to offer advanced industry ready skills in the field for interpreting the fractographs using electron microscope to become a trained failure analyst

Venue : ICON Labs, Sanpada New Mumbai
Date: Jan./Feb. 2023 [Saturday- Sunday]

THE COURSE COVERAGE of Module 1 :

- Introduction: Working Principle
- Types of EM : TEM/ SEM/ ESEM/ STEM
- Macro & Micro fractography of Tensile, Fatigue, wear, corrosion & Environment assisted Fractures
- How to conduct root cause failure analysis & forensic investigation of Bearings & Brake discs using Electron microscopes

Registration Charge :Rs. 10000/- per participants

The total intake is restricted to maximum 10 based on first come first served

For further information Contact Prof. R. C. Prasad at rssppa@gmail.com, rcprasad@mes.ac.in, sfa.mes.ac.in

Activities Proposed

Two Days Intensive Workshop
On
Fracture Mechanics & Failure Analysis: Research Opportunities to Solve Industrial Problems

Organised by

PHCET — Pillai HOC College of Engineering & Technology | Institution's Innovation Council | SFA Mumbai Chapter

Preamble

The Industry today faces challenges to prevent degradation and failure of its ageing infrastructure. Failures eat 4-5% of the economic output of a developing country by reducing the production efficiency and the increasing the cost of production. Fracture performance is a matter of serious concern. Systematic analysis of the cause of failure and taking suitable preventive methods is essential for the economic growth of the country. Fracture control based on conventional design using charpy and tensile tests are considered no longer adequate to ensure safety and reliability. A large number of components are retired prematurely because of lack of our knowledge in determining useful life. The industries ensure structural integrity by periodic inspections. However the decision on inspection, repair and maintenance so far has been made based on experience. This needs to be rationalized through integration of Fracture mechanics, NDE and Failure analysis. The combined advances in these areas have radically changed the approach to design and manufacturing in recent times. Fracture mechanics and Failure analysis have emerged as powerful tools in designing processes and products to enhance operational efficiency and safety. Industries today need a skilled manpower conversant with Fracture mechanics and Root cause failure analysis. This Workshop is designed to provide training and learning to cover the gap between the syllabus prescribed by Universities and the Graduate attributes required by the Industries. The objective is to bridge the knowledge gap between existing course curriculum and connect academic research with Industrial problems. It intends to develop a skill and sound understanding of how to evaluate products and processes, predict and eliminate defects, increase productivity and quality at decreased cost.

Course coverage (SEPTEMBER 26-27,2023)

The following topics are tentatively planned to be covered

- Defects leading to fracture, Role of Failure analysis in design
- Basic approaches to failure analysis
- Overview of Fracture Mechanics and Defect tolerant design
- Determination of material toughness parameters like K_{Ic}, J_{Ic} and CTOD
- Application of Fracture mechanics for Fatigue and Environmental assisted cracking
- Detection and characterization of defects using NDT techniques
- Degradation monitoring, Life assessment and its extension
- Quantitative NDE for fitness for purpose assessment.
- Modes and Mechanism of Failure and Root cause failure analysis
- Corrective and preventive measures to minimize failures in different sectors of industries
- Application Fracture mechanics in failure assessment diagram and industrial problem solving

The theory lectures shall be supplemented by hands-on training on fracture toughness testing and fracture characterization using optical and electron microscopy

Faculty

Faculty will be drawn from educational institutes and research establishments like IITs and Department of Atomic Energy as well as from outside research establishments including industry.

Registration Charges

Category	Fees
SFA & Members of other professional societies	3000/-
Non Members	5000/-
Faculty Members	1500/-
Student Participants	500/-

The event can be sponsored by donating Rs. 25000/-

Sponsorship entitles mention on banners and free registration for two delegates.

Coordinator

Prof. R.C. Prasad

Department of Mechanical Engineering, PHCET, Rasayani

Mobile.:- 09869236812 Fax :- 2748 3208

Email.:- rsppa@gmail.com / rcprasad@mes.ac.in

Web.:- www.sfa.mes.ac.in

Payment may be made through DD / Cheque drawn in favor of'R&D PHCET.

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- Powai Marathi Madhyamik Shala - *Powai*
- Mahatma School of Academics and Sports - *Khanda Colony, New Panvel* (Pre-Primary, Primary & Secondary, English & Marathi Media)
- HOC International School - *Rasayani* (English & Marathi Media)

(CBSE PROGRAMME)

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- Mahatma Night Junior College - *Chembur*
- Mahatma School of Academics & Sports, Junior College of Arts, Science & Commerce *Khanda Colony, New Panvel*
- HOC Junior College - *Rasayani* (Junior College of Arts, Commerce, Science with Vocational)

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Approved by National Council for Teacher Education (NCTE) (Affiliated to the University of Mumbai & Recognised by Govt. of Maharashtra.)

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- Pillai College of Education & Research (B.Ed.), Chembur Re-Accredited 'A' Grade by NAAC
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  B. E. in Electronics Engineering
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  B. E. in Electronics & Tele- communication Engineering
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  M. E. in Computer Engineering
  M. E. in Electronics Engineering
  M. E. in Mechanical Engineering (CAD/CAM, Robotics)
  M. E. in Mechanical Engineering (Thermal)

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  B.E. in Automobile Engineering
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  M.E. in Computer Engineering
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