Ed Hare, Ph.D.

Materials Scientist • Failure Analyst • Engineering Consultant

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A Technical Career in Materials and Electronics Engineering

From Laboratory Practice to Remote Consulting and AI-Assisted Analysis

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Objective and Preface

The purpose of this document is to explain the origins and evolution of SEM Lab, Inc., from Ed Hare's early laboratory work in the late 1970s through the present transition toward data-driven and AI-assisted analysis. It is written primarily for engineers, who like us value direct evidence, clear reasoning, and the continuity of technical knowledge.

The sections that follow describe the work as it occurred: manufacturing, analysis, and teaching in the context of changing technologies. The intention is to illustrate the lessons that shaped a career and a laboratory.

SEM Lab, Inc. was founded with the simple goal of providing reliable analytical support to high-technology industries. Decades later, that same goal continues through remote consulting and digital tools designed to preserve and extend what has been learned.

This document describes a traceable account of that progression—how laboratory practices evolved and what future engineers can gain from tapping into this knowledge source.

Meyercord Company, 1978–1979

My first position after McHenry County College (ASChem '78) was in the ceramics laboratory at Meyercord Company in Carol Stream, Illinois. I worked under a ceramics engineer developing and testing ceramic inks used for half-tone screen printing on cookware and bottle labels. The inks were blends of ceramic pigment and organic vehicle, printed through screens onto test substrates, then fired in a convection furnace to form a durable glass-ceramic finish.

The lab operated with well-defined procedures. Each formulation was documented by weight and solvent ratio, the screens were checked for uniform deposit thickness, and every fired sample was evaluated for color match and surface quality. Results were compared with customer specifications before approval for production.

Because many designs had not yet reached the market, finished samples were destroyed after testing. Corning Corelle plates were particularly resistant—several full hammer blows were often required to fracture them. That exercise provided an early appreciation for the strength of glass-ceramic materials and for the discipline required to maintain consistent screen-printing performance.

The experience established a foundation in materials behavior, process control, and the importance of repeatable methods—principles that carried forward into later work with metals and electronic materials.

Northwest Technical Industries, 1979–1983

After leaving Meyercord, I joined Northwest Technical Industries in Sequim, Washington, as a project engineer. The company specialized in explosive metal fabrication—using controlled detonation to bond dissimilar metals and form specialized structures for industrial and defense applications. My responsibilities included both research and development and direct manufacturing engineering support.

Work in this environment required a combination of precision and caution. Each setup demanded accurate charge design, initiation geometry, and confinement control to produce reliable bonds without introducing unwanted deformation or delamination. Post-bond evaluation involved sectioning, metallographic examination, and acoustic testing to verify bond integrity and uniformity.

During this period, I worked closely with scientists from several U.S. national laboratories, including Argonne, Lawrence Livermore, Lawrence Berkeley, and Battelle. Collaboration also extended to engineers and scientists from major defense contractors such as Lockheed and United Technologies, as well as the Department of Defense and the U.S. Navy at Puget Sound Naval Shipyard. These projects broadened my understanding of high-energy forming processes, joining technologies, and nondestructive evaluation methods used in critical defense and research programs.

I also learned about acoustic properties of materials and was responsible for measuring detonation velocities of various explosives. This provided early experience in theoretical materials behavior and practical test design.

The work at Northwest Technical Industries introduced me to energy-based forming processes and the importance of metallurgical interfaces. It was an unconventional but valuable foundation for later work in electronic packaging, where controlled joining and interface reliability became central themes.

University of Washington, 1980–1994

I began formal studies in Metallurgical Engineering at the University of Washington in 1980 while continuing to work part time for Northwest Technical Industries during the summers.

That balance of academic theory and applied industrial work reinforced a practical approach to materials science that stayed with me throughout my career.

Coursework focused on metallurgy, materials characterization, and mechanical behavior. The program provided access to research facilities and laboratory methods that complemented the process-oriented experience I had already gained in explosive bonding and metal fabrication.

During this period, I met my future wife and business partner, Liz Riemer, in class. We shared similar academic interests in materials science and engineering. She later became the co-founder and President of SEM Lab, Inc., established in 1997.

I completed the Bachelor of Science degree in Metallurgical Engineering in 1983 and chose to move from large-scale metal processing toward electronics manufacturing and reliability. That decision led to a position with Honeywell Marine Systems in 1984 and concurrent enrollment in a master's program at the University of Washington, marking the start of a long focus on electronic materials and packaging technology.

Honeywell Marine Systems and Boeing Electronics Company, 1984–1987

After completing my bachelor's degree in 1983, I joined Honeywell Marine Systems Division in Seattle as an electronic packaging engineer while also entering a master's program in metallurgical engineering at the University of Washington. The work involved development of advanced packaging concepts for high-reliability electronic assemblies, focusing on surface mount technology, interconnect design, and materials selection.

I worked in the Electronic Packaging group, supporting both design and process development. The environment was technically demanding and provided exposure to new methods in automated assembly and fine-pitch soldering that were still emerging in the mid-1980s.

A recession later affected the division, and I was offered the choice of layoff or transfer to Honeywell Technical Services in Poulsbo, Washington. I accepted the transfer and commuted by ferry for roughly ten months. The position involved direct support for Navy programs at the Naval Underwater Weapons Engineering Station (NUWES) and the Bangor Submarine Base. My role included liaison with Navy engineers on surface mount rework & repair for defense electronics systems in the field.

The work was technically interesting but logistically difficult, and after that assignment I accepted a position with Boeing Electronics Company in Renton, WA. There I continued process development in surface mount and soldering technologies, applying both metallurgical and manufacturing experience to avionic electronics development.

Honeywell Marine Systems and Alliant Techsystems Inc., 1987–1996

In 1987 I returned to Honeywell Marine Systems, this time in Mukilteo, Washington, as a Senior Materials and Processes Engineer. My work centered on developing high-density surface mount assembly processes for defense electronics, including lead forming and tinning, fine-pitch component placement, and controlled solder reflow. The goal was to improve process yields and reliability through data-driven methods.

I applied Design of Experiments and Statistical Process Control techniques to refine soldering and assembly operations. These efforts led to the development of several specialized computer-controlled assembly machines: a semi-automatic fine-pitch placement system, a fully automatic tinning system, and a focused infrared soldering system for connectors. For this work I received Honeywell's Technical Achievement Award.

Around 1989–1990, Honeywell spun off most of its defense-related operations, and our group became part of Alliant Techsystems Inc. The technical focus remained the same, but the environment shifted toward a leaner, contract-oriented model. I continued as Principal Materials and Processes Engineer in the Product Analysis Laboratory, performing failure analysis, SEM/EDS characterization, construction analysis, non-destructive testing, and materials support for a range of OEM electronic and electro-acoustic products.

During this period, I began a Ph.D. program in Materials Science and Engineering at the University of Washington, with research focused on solder materials, mechanical behavior, and reliability prediction. Graduate study complemented the industrial work, providing theoretical background in creep deformation, and failure mechanisms that I could apply directly to ongoing production and analysis tasks.

Over this period, I completed more than 900 analytical tasks involving integrated circuits, hybrid circuits, discrete components, magnetics, surface mount and through-hole assemblies, printed wiring boards, thick-film ceramics, mechanical components, and injection-molded plastics. I also developed an automated computer-controlled power cycling test system for evaluating printed wiring board reliability and supplier quality.

This phase consolidated my experience in both process development and failure analysis. It also established the foundation for my later transition to independent laboratory work, where those same analytical methods became the core of SEM Lab's capabilities.

Intermec Corporation and SEM Lab, Inc., 1996–Present

In 1996 I joined Intermec Corporation in Everett, Washington, as a Senior Quality Engineer in the Product Assurance organization. My responsibilities included root cause failure analysis of dead-on-arrival (DOA) products, supervision of four failure analysis technicians and five product quality auditors, and management of the corporate failure database. The work involved frequent interaction with design, manufacturing, and supplier quality groups to identify emerging failure trends and implement corrective actions.

I developed new analytical methods for failure classification and published a monthly DOA report summarizing failure rate by product model. The position provided a clear view of how field performance, factory process variation, and supplier control intersect to determine product reliability.

SEM Lab Inc.— Three More Decades of Applied Failure Analysis

In late 1997 I decided to move toward independent laboratory work and founded SEM Lab, Inc., in Snohomish, Washington. My wife, Liz Riemer, became President, managing business operations while I served as Vice President and technical lead. The lab was established to provide Scanning Electron Microscopy (SEM), Energy Dispersive Spectroscopy (EDS), and related analytical services for electronics manufacturers and materials developers.

SEM Lab's focus was on practical problem solving—supporting product development, materials characterization, and failure analysis for high-technology industries. Early clients included aerospace, telecommunications, medical electronics, and consumer electronics companies. The lab built a reputation for technical accuracy, clear documentation, and the ability to translate microscopic evidence into actionable engineering recommendations.

Over time, the scope of work expanded to include cross-sectional analysis, metallography, and specialized investigations such as ENIG finish evaluation, solder joint embrittlement, corrosion, and plating defects. The laboratory has maintained continuous operation since its founding, adapting to each wave of materials and process changes in the electronics industry, from tin-lead to lead-free soldering and beyond.

In recent years, the emphasis has shifted toward digital knowledge capture and applied analytics. The extensive body of laboratory data accumulated over decades has become the foundation for AI-assisted tools and database-driven analysis designed to preserve and extend the knowledge base of electronic materials and failure mechanisms.

SEM Lab, Inc. remains focused on the same original objective: providing analytical and engineering support in product development, materials and processes, and failure analysis for high-technology companies.

Since its founding in 1997, SEM Lab Inc. has operated as a specialized analytical laboratory focused on failure analysis and materials characterization for electronics manufacturing. The original mission was straightforward: apply scientific measurement and disciplined engineering methods to real production problems.

Over three decades the laboratory supported hundreds of companies in aerospace, telecommunications, medical, and consumer electronics. Projects have ranged from component failure analysis, solder joint reliability studies, plating defect analysis, and component contamination assessment. The laboratory's work has documented every major transition in electronic assembly materials—from eutectic tin–lead to lead-free solders, from conventional gold plating to electroless nickel immersion gold (ENIG) finishes, and from thick-film ceramics to advanced printed circuit substrates.

Core capabilities have included scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDS), FTIR spectroscopy, metallography, optical microscopy, and mechanical sectioning. Each investigation produced detailed documentation linking physical evidence to manufacturing processes and field performance.

The laboratory remained intentionally small, emphasizing technical rigor and continuity of judgment over volume throughput. Every analysis was reviewed and written personally, maintaining consistency in interpretation and reporting style.

SEM Lab also served as a regional training resource, providing guidance to local manufacturers on soldering process control, plating quality, and materials selection. Publications and conference presentations extended that reach nationally.

Through this period, Liz Riemer managed operations as President, maintaining business stability and client relationships while I directed technical programs. Together we kept the lab focused on its original objective: reliable analytical support grounded in direct evidence.

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Overview

Ed Hare, Ph.D., is a materials scientist and electronics failure analyst with more than forty years of experience in product reliability, metallurgical characterization, and microanalysis. His work spans manufacturing, research, and consulting roles within Honeywell, Boeing, Alliant Techsystems, and Intermec before founding SEM Lab, Inc. in 1997.

Technical Expertise

- Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (EDS)
- Solder metallurgy and intermetallic behavior
- Surface finishes (ENIG, electroplated Au, Ni-P barriers)
- Printed wiring board and micro via reliability
- Root-cause failure analysis and corrective-action support
- Process development and statistical process control

Career Highlights

- Honeywell / Alliant Techsystems (1987–1996): Developed high-density surface-mount processes and automated assembly systems; received Honeywell Technical Achievement Award (1988).
- Intermec Corporation (1996–1997): Senior Quality Engineer; supported corporate DOA failure-analysis program.
- SEM Lab, Inc. (1997–Present): Independent laboratory providing analytical services for aerospace, defense, telecommunications, and electronics manufacturers. Conducted thousands of investigations involving solder joint reliability, plating defects, and materials contamination.
- Academic / Professional Contributions: Ph.D. in Materials Science and Engineering (UW 1994); publications and conference papers on solder behavior, gold embrittlement,

and diffusion-barrier plating; invited lecturer for the University of Washington MSE 431 Failure Analysis course (2011).

Consulting Focus

Remote consulting in materials and process evaluation, failure-mechanism diagnosis, and reliability improvement. Emphasis on concise interpretation of analytical data and practical engineering recommendations.

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Appendix A: Publications and Technical Contributions

The following publications document the technical development of my work from academic research through applied laboratory practice. They trace the progression from fundamental metallurgy to practical reliability issues in electronic assemblies.

| **1985** | *Structure and Property Changes during Room Temperature Aging of Bismuth Solders* | *Electronic Packaging: Materials and Processes*, St. Paul MN | Early study of microstructural stability in Bi-based solders. |

| **1986** | *Anomalous Temperature Dependence of the Electrical Resistivity of Ti–Ni and Ti–Fe Alloys* | *University of Washington* | Graduate research linking phase constitution and resistivity. |

| **1990** | *Electrical Resistivity–Constitution Relationships in Ti–Fe and Ti–Ni Alloys* | *Journal of Materials Science: Materials in Electronics 1 (1)* | First peer-reviewed publication. |

| **1994** | *Stress Relaxation Behavior of Eutectic Tin–Lead Solder with Silver and Copper Additions* | *University of Washington (Ph.D.)* | Doctoral dissertation. |

| **1995** | *Stress Relaxation Behavior of Eutectic Tin–Lead Solder* | *Journal of Electronic Materials 24 (10)* | Co-authored with R. G. Stang; frequently cited study of solder creep behavior. |

| **2007** | *Diffusion Barrier Plating in Electronics* | SEM Lab Inc. Technical Paper | Review of Ni–P barrier layers and gold over-plating performance. |

| **2010** | *Gold Embrittlement of Solder Joints* | SEM Lab Inc. Technical Paper | Analytical case studies on $AuSn_4$ intermetallic formation. |

| **2012** | *Failure Analysis of Aluminum Electrolytic Capacitors* | SEM Lab Inc. Technical Report (with E. Riemer) | Field failure mechanism survey. |

| **2013** | *Intermetallics in Solder Joints* | SEM Lab Inc. Monograph | Overview of intermetallic structures and reliability implications. |

| **2015** | *FTIR Analysis* | *SEMLab.com* | Application note on polymer and contamination identification. |

These publications represent the formal record of work that began with solder metallurgy research and matured through decades of applied failure analysis and surface finish reliability studies at SEM Lab Inc.

Appendix B: Presentations, Awards, and Recognition

Awards

1988 — Honeywell Technical Achievement Award

Received Honeywell's Technical Achievement Award for development of automated assembly equipment used in fine-pitch electronic packaging.

The project included:

- A semi-automatic fine-pitch placement system

- A fully automatic fine-pitch tinning system

- A focused infrared connector soldering system

A companion feasibility study evaluated implementation of the Vanzetti Solder Inspection System for fine-pitch surface-mount assemblies.

Technical Presentations

"Applications of SEM/EDS and Failure Analysis in Electronics Manufacturing"

SAMPE Northwest Chapter Meeting – SeaTac Holiday Inn, September 26, 2000

Presenter: Ed Hare, Ph.D., SEM Lab, Inc.

An overview of scanning electron microscopy (SEM) and energy-dispersive spectroscopy (EDS) applied to manufacturing and reliability problems in electronics.

Topics included plated-through-hole (PTH) cracking, copper-oxide defects, BGA solderability issues, ENIG “black pad” failures, gold-embrittlement in solder joints, and device-level EOS and electromigration damage.

This presentation introduced many regional engineers to the use of SEM/EDS as a standard problem-solving tool in production environments.

****“Images of Failures in Microelectronics Packaging and Assembly”****

IMAPS Northwest, February 11, 2004 – Redmond, Washington

Presenter: Ed Hare, Ph.D., SEM Lab, Inc.

A visual summary of common microelectronic failure mechanisms documented through SEM/EDS analysis, including:

- Inner-layer separation and micro via defects

- Drill breakout and annular-ring criteria

- Electrical overstress (EOS) failures

- Bond-pad corrosion and dendritic growth

- BGA damage and ENIG “black pad” syndrome

- MLCC and resistor-network fatigue failures

- Electromigration and dendrite formation in lead-frame packages

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Teaching and Academic Contributions

****Guest Lecturer – MSE 431: Failure Analysis****

University of Washington, Department of Materials Science and Engineering – September 2011

Invited by Dr. Brian Flinn to contribute to MSE 431 (Failure Analysis). Participation included classroom discussion and presentation on analytical methods used in industrial failure analysis. This collaboration strengthened ties between SEM Lab Inc. and the University’s Materials Science program.

Other Professional Activities

- Regular contributor and participant at IMAPS Northwest and SMTA regional meetings.

- Invited seminars on solder-joint reliability, gold embrittlement, and ENIG finish evaluation for aerospace and electronics manufacturers in the Pacific Northwest.

- Maintained **semlab.com** as a public repository of technical notes and case studies.
