

## A Perspective on the Reliability of MEMS-Based Components for Telecommunications

½ Day Course

### ABSTRACT

Despite the initial skepticism of OEM companies regarding reliability, MEMS-based devices are increasingly common in optical networking. This presentation will discuss the use of MEMS devices in a variety of network applications, from tunable transponders, filters, and receivers to variable optical attenuators, wavelength selective switches, and optical switches. The failure mechanisms of these devices will be addressed in terms of reliability physics, packaging methodologies, and process controls, with differentiation between the occurrence and mode of failures observed during production and in extended field use. Typical OEM concerns and requirements will also be presented, including testing beyond of the scope of conventional Telcordia qualification. The key conclusion is that, with sufficiently robust design and manufacturing controls, MEMS-based devices are substantially more reliable than many mature and extensively-deployed optical components.

### OUTLINE

- Background
  - John C. McNulty, Ph.D.
    - Manager / Director of Reliability of two telecom start-ups producing MEMS-based devices
    - Member of Telcordia GR-468 revision committee, involved in implicit incorporation of requirements that relate to MEMS (predominantly operational shock and vibration testing)
- Introduction
  - MEMS have been reliably employed in high volume applications (e.g. accelerometers and projection) for many years
  - There is a steady increase in the use of MEMS in telecommunications (e.g. optical switching, power leveling/control, tunable lasers & filters, and OADM applications)
- Typical Devices
  - Overview of 4 MEMS-based products including their key features
- MEMS Failure Mechanisms and Mitigation
  - Fracture (particularly surface- and volume-dependent strength)
  - Fatigue
  - Stress corrosion cracking
  - Stiction
  - Wear
  - Particulate- and water vapor-induced shorting
  - ESD damage
- Testing & Analysis Methods During Product Development
  - Design: finite element analysis
  - Process development & control: wafer and etch characterization
  - Evaluation: operational vibration, particularly open vs. closed loop control
  - Screening: shock and vibration testing to screen out defective units
  - Qualification: test methods
- Telcordia vs. OEM Reliability Requirements
  - Potential differences with respect to operational and non-operational shock and vibration, as well as endurance tuning/switching
- Case Study: Qualification Testing and Failure Mechanisms/Rate Analysis for a Tunable Laser Product
  - Summary of testing and observed failure modes
  - MEMS failures limited to likely process escapes
  - MEMS-based failure rates compared to common passive & discrete electronic components
- Conclusions