Progress Towards Standardization of Alpha Flux Measurements in Electronic Materials

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Outline

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- Overview of current metrology capability relative to industry requirements
- Identify challenges and gaps to close
- Discussion of Standard and problems solved
  - Compensation for different instrument settings
  - Background determination
  - Systematic error detection and correction
- Continuing challenges
  - Universal reference material
  - Improved instrumentation
- Future hurdles to overcome

An upstream materials perspective to SER issues

The Problem

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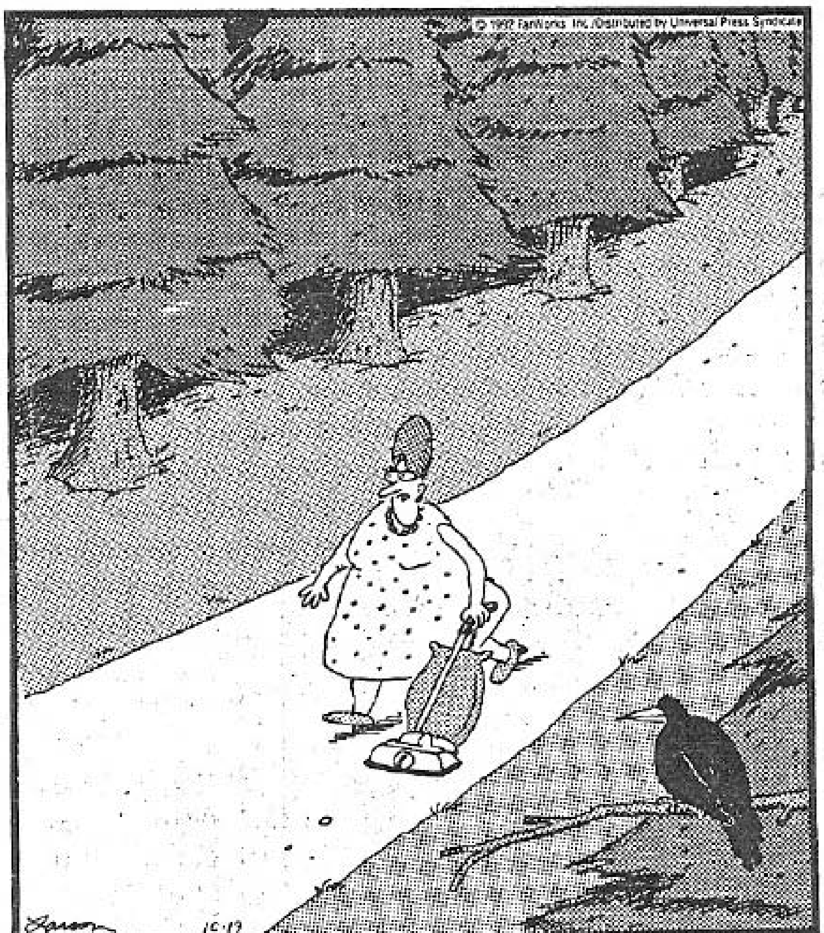
THE FAR SIDE • Gary Larson



The woods were dark and foreboding, and Alice sensed that sinister eyes were watching her every step. Worst of all, she knew that Nature abhorred a vacuum.

Create and maintain an artificially low radiation flux environment where IC components may function reliably without damage!

IC Materials Overview

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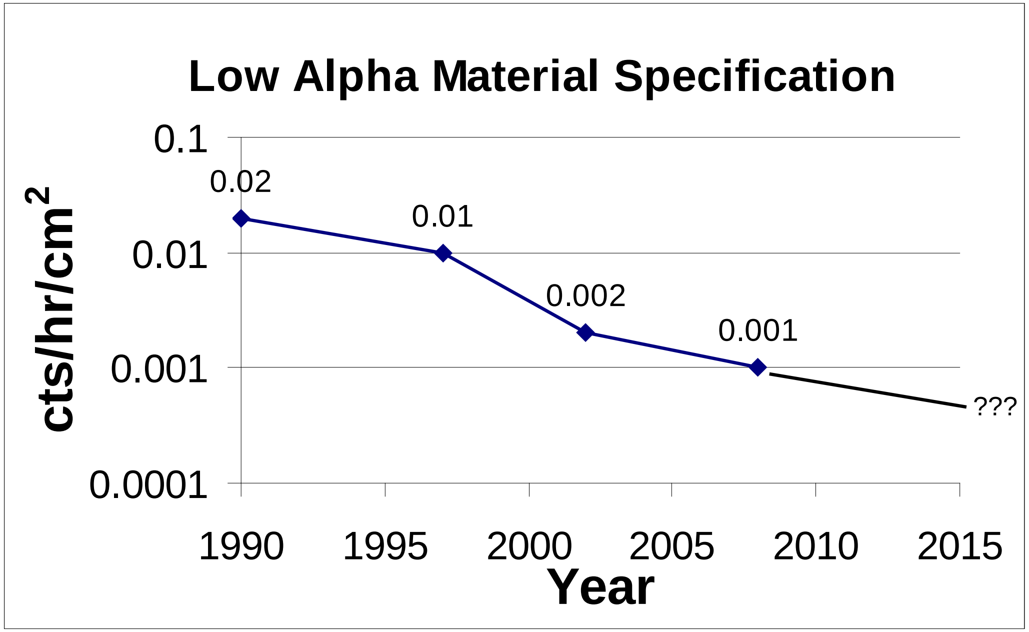
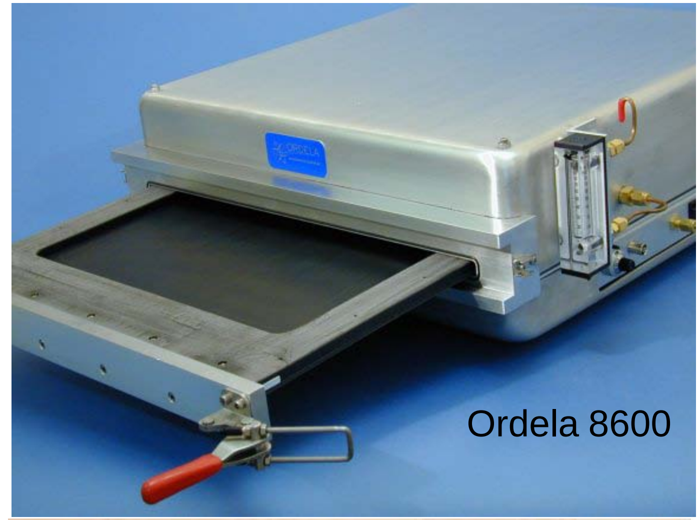
- High purity materials, metals, alloys
- Alpha Radiation sources
  - ^{210}Pb in Pb/Sn solders
  - U and Th + associated daughters
  - Cosmic
- Alpha Activity Requirements
  - 0.02 $\alpha \cdot hr^{-1} \cdot cm^{-2}$: 1990's
  - 0.002 $\alpha \cdot hr^{-1} \cdot cm^{-2}$: 2001
  - 0.001 $\alpha \cdot hr^{-1} \cdot cm^{-2}$: 2008



Specifications 2-3 orders of magnitude below ambient!

Gas Proportional Counter Summary

- Several OEM's
- Area :1000 - 4000 cm^2
- Geometry: 4π
- Background
  - 2-3 cph optimal, 4-6 nominal
- Lack energy spectroscopy capability
  - Limited ability to identify specific radioisotopes
- Relatively simple, inexpensive instruments



Ordela 8600

Alpha Sciences 1950

Instrumentation capability lagging material requirements

Instrument Capability Then and Now

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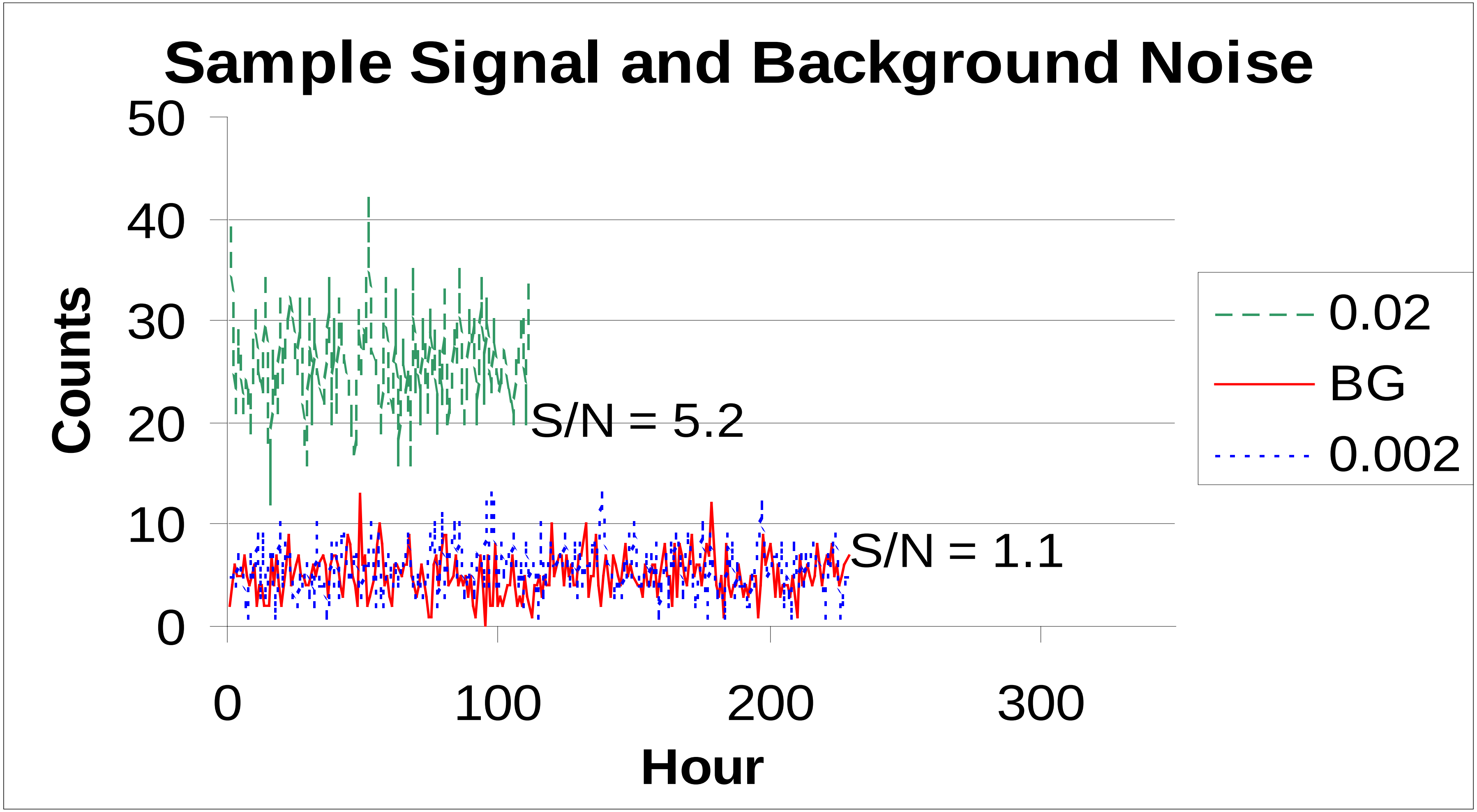

Standard measurement methodology needed

JEDEC 13.4 Subcommittee (Radiation Hardness)

- **JC 13.4 Subcommittee sponsored standard in 2004**
- **Task group convened to identify and address issues**
- **Solicited input from JEDEC member companies and others willing to contribute**
- **Establish best measurement practices**
- **Prescriptive in critical elements, descriptive in informative elements**
- **Focused on gas proportional systems prevalent in the industry and associated supply chains**
- **Quantify sources of variation between different laboratories**

Contributors

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- Brett Clark – Honeywell
- Rob Baumann – TI
- Norbert Sieffert, Jack McMullen – Intel
- Dan Chesire – Agere
- Michael Gordon, Mark Burns – IBM
- David Bollinger – Air Liquide
- Keith Forbes – Motorola
- Rick Wong – Cisco
- Ken Patterson – Avago
- Gilles Gasiot – STMicro
- Keith Lepla – Teck Cominco
- Guenter Schindlbeck – Infineon
- Michael Tucker – Alpha Sciences
- Jeff Wilkinson – Medtronic
- Richard Blish – Spansion
- Bruce Euzent – Altera
- Barry Carroll – Freescale
- Miguel Vilchis – LSI

Task #1: Standardize Instrument Parameters

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- Remove variability between different laboratories due to instrument settings
- Method for setting optimum bias voltage
- Method for setting discriminator
  - Instruments measuring different energy ranges
  - Generally accepted energy range from 1.2-9 MeV
- Method for measuring detector active area
  - Some detectors have “dead zones”, so results were biased low
- Sample distance specified

Instrument variation controlled or compensated

Task #2 Background Determination

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- Critical when dealing with low signal/noise
- Background measurement errors propagate to significant error in results
- Method for determination
  - Before/After method
  - Long term average of statistically controlled background
- Contributions of stages or trays
- Prescribed time for counting background relative to precision

Eliminate common discrepancy between laboratories

Task #3 Addressing Systematic Errors

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- Identification
  - Cumulative Density Function
  - F statistic
- Treatment of outliers
- Method for determining count rate stabilization and rejection of initial data
- Specific examples of contamination and associated corrections
  - Contamination from cleaning materials
  - High background
  - High initial readings

Statistically robust measurement process

Task # 4 Miscellaneous Issues

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- Detection limit definition and sample calculation
- Secular equilibrium considerations
  - For Pb products, possibility of alpha flux increase
  - Report time interval between processing and measurement
- Uniform format for reporting data
- Annexes for examples
  - Active area determination
  - Application of cumulative density function for identifying systematic errors
  - Alpha emissivity result and error calculation example

25 pages, 7 Sections, 3 Annexes

Current Status of Standard

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- Joint JC13.4 and JC 14.1 ballot in June 2009
- 6 Yes
- 4 Yes with comments
- 4 No with comments
- 2 No Votes addressed and changed
- 2 Additional votes to be addressed
- Once consensus is reached, final draft goes to JEDEC Board of Directors for final vote

Standard document is a significant step forward, but our work is not done

Continuing Challenges

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- Universal calibration standard material
  - Great in theory
- Practicality?
  - DOT prohibitions to shipping radioactive material
  - Stable activity for years
  - Acceptable emissivity rate
  - Correct energy range
- Such a standard has not been identified yet
- In lieu of a calibration standard, the document requires correlation studies between the two labs before results can be certified as equivalent

When acceptable material is identified, proceed with document revision

Building a Better Mousetrap?

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- Measure increasingly low activity levels in timely manner without loss of precision
- A significant challenge confronting the industry
- Increase signal/background ratio
  - Increase detector area while maintaining background
  - Decrease background
- Future possibilities
  - Large area solid state detectors
  - Pulse shape discrimination techniques
  - Scintillation counting

If you cannot measure, you cannot improve.
- Taguchi

Best case scenario: Timely, Precise Analysis

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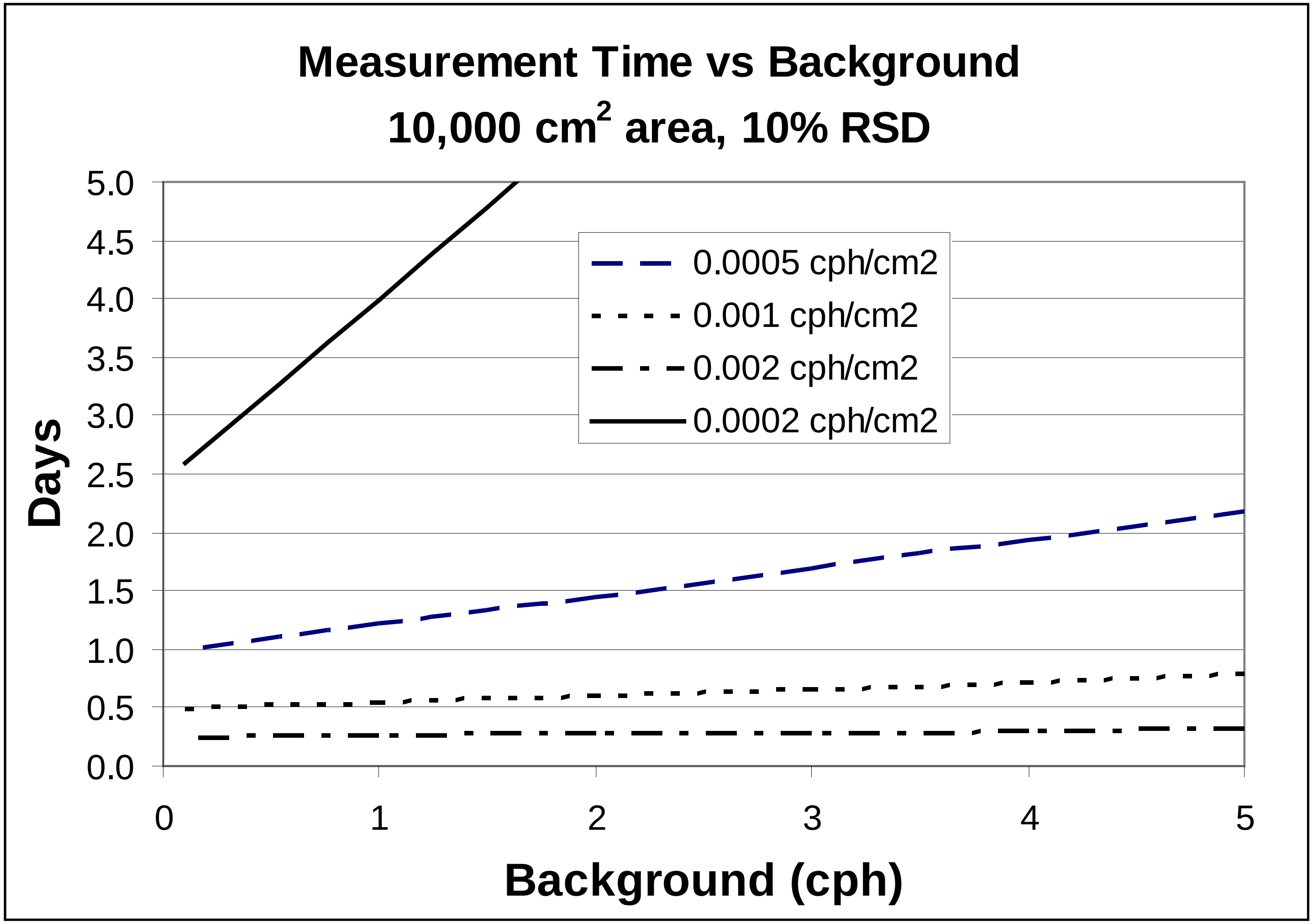

How low will we go?

Conclusions

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- IC roadmaps continue to require lower activity materials
- Industry metrology challenges are non-trivial
- Standard document has been developed to maximize current instrumentation capability
- Industry demands for increased reliability will place a premium on alpha metrology capability
- Metrology must improve significantly to be capable for future requirements
- As instrumentation changes to meet future industry demands, the JEDEC standard is a foundation to build on

Acknowledgements

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- Rob Baumann, Texas Instruments: Co-chair
- JC13.4 Subcommittee
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  - Chuck Tabbert
  - Reed Lawrence
- JC14.1 Subcommittee
  - Charlie Slayman
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