<u>Notes from the IRPS 2017 Extrinsic Reliability Workshop – Cypress Room – April 4, 2017</u>

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29 participants

Introduction

- Despite all the work on intrinsic reliability, most of the failures are extrinsic in nature.
- Need to focus on design, pre-manufacture, test and release.
- SER is a possible exception for large scale systems and needs to be considered in addition to extrinsics
- At the system level, thermomechanical and environmental fails are significant.

Understanding

We don't do a lot of work on the following for extrinsic defectivity:

- Statistics – sample sizes need to be large to see anything extrinsic in nature
- IP – related to process engineering and yield – difficult to share data due to proprietary nature
- Diverse or process specific fail mechanisms make modeling fails difficult.

History

- Baseline for understanding extrinsic defect modeling comes from a paper by Intel -
- "Reliability versus yield and die location in deep submicron VLSI" which won the 1999 IRPS best paper.
- Data was ell correlated with process yield
- Defect modes accelerated by V and T to detect declining fail rates – amenable to screening with burn-in
- Dominated by hard (short) defects
- BI may be necessary for large, complex die such as microcontrollers, SBC chips, DSP, ASICs, etc.

Nature of extrinsic defects

- Patterning defects are random, depends on geometry
- Gate oxide defects are random, but can be dependent on wafer, dielectric thickness, etc.
- Future landscape will be more more complex as geometries scale down and new materials and interfaces can present new, unknown fail mechanisms and modes.

- Extrinsic failures need to be engineered out.
- Voids/opens are a concern because it is difficult to test and accelerate with frequency. Wafer level burn-in could help in certain ways but can't accelerate frequency.
- GOX defects are no longer dominant, defects between increasingly scaled down metallization densities are becoming dominant for extrinsics.

- Shorts are very subtle in nature, especially in terms of detectability.
- Shorting fails usually are highly voltage accelerated.

- Can guardband effects based on extrinsics as long as you understand the effect.

- OEM view - 20% of returns are defect related. From that, 80% is assembly related.

New customer applications

Growth applications raising the bar for extrinsic defect detectability, occurrence and severity

- Large scale systems and infrastructure (Cloud, HPC)
- Autonomous safety systems (ADAS, robotics)

Cost pressures at all levels of integration, especially on the need for burn-in and screening

Technology scaling:

- Density and lack of Voltage scaling
- Slower techology cadence/maturation
- Attenuation of conventional wisdom
    - Extrinsic may be less random than is normally thought
    - There is less consistent correlation of yield and latent reliability
    - Defects are more subtle
    - Sufficiency and technical challenges of burn-in less than it was

Extrinsic defectivity issues – plotting the data

- Ideally, we want to use Weibull or lognormal to map the distribution of failures if possible, but you need large sample sizes, and these plots cannot be easily extrapolated without sound experimentation design.
- Distribution fits aren't what they seem (use different GOX thicknesses)
- Extrinsics may not fit a classical distribution model (normal, lognormal, Weibull) or are easily modelled due to the relative paucity of identifiable occcurrences and causes (e.g., damage destroyed the evidence).

Extrinsic defectivity issues – modeling the fail mechanism

- Outliers can be significant and difficult to model even with large sample sizes.
- From an OEM point of view, intrinsic oxide failures can be modeled, where an accelerated stress shows an extrinsic tail, but normal conditions showed nothing. Also, there has been observed a change in distribution model slope. The voltage wasn't scaled, but they continued to be susceptible to failure. Now have a lot of competing fail mechanisms that interact.
- Burn in (thermovoltaic or voltaic) has the possibility of shortening the life of good parts
- Extrinsic defectivity is difficult to model because you can predict probability of defect occurrence based on defect density but you don't know the actual model for the extrinsic defect (e.g., crystalline defect versus charge trap for TDDB).
- Big data and robust traceability of customer returns might be an answer to determine the process excursion that might have created the extrinsic defect.