Interfacial Mesoscopic Structuring As a Highly Probable Origin of the Mysterious “LER Fundamental 5nm-Limit“

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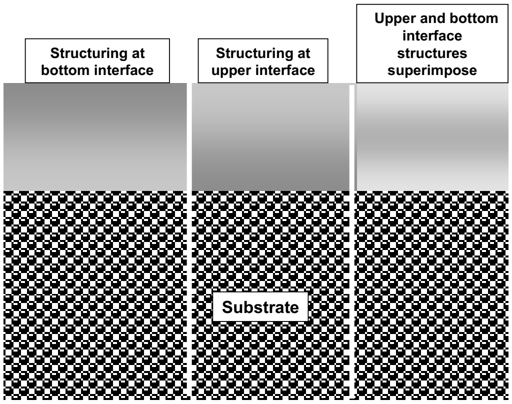
Litho-caused LER is considered as one of the major stumbling blocks complicating the progress in the semiconductor technology. Line edge profiles demonstrate that low frequency components are clearly dominating in the roughness spectrum, indicating large characteristic length phenomenon(a), λ >100-500 nm, to be the major LER source. Numerous LER improvement efforts have showed LER to level asymptotically at 4-5 nm refusing to show any further response to the resist “improving” efforts, which gave reasons for the term “LER fundamental limit” (YG: read “LER mysterious limit”) to appear. Most of the theoretical analyses aimed to identify the origin of the LER were predominantly focused around the exposure statistics, resist contrast and CAR catalytic action, although it becomes more and more clear that that large scale of the edge waviness could not appear due to resist photon/electron activation statistics or to CAR chemical transformations during the exposure and PEB steps.

Resist and resist processing liquid films gradually get more and more thin, leaving the film with only upper and lower interfacial highly gradiental sections and practically with no uniform bulk section. With no bulk left UTFs become highly interfacial with interfacial phenomena dictating the dominant (and in many cases completely new) rules of the game. UTF loose their most fundamental attribute- constancy of basic properties (MP, BP, Density, optical parameters, T/D parameters, etc.). UTF properties become strongly dependent on film thickness, substrate(s) nature, surface state and so on. UTF(s) are strongly influenced by interfacial instabilities and interfacial dynamics, which strongly modifies (sometimes even mutates) the UTF processing responses Even conventional theories, developed in terms of properties as constants, become non-applicable for UTFs, requiring revision.

Due to interfacial activity liquid UTFs are never static, never flat and never uniform, neither thermally nor chemically or structurally.

Liquid film structural non-uniformities are inevitably transferred into the film post-evaporation/drying products, which strongly influences all UTF responses during its processing. There is absolutely no reason to hope that resist processing will proceed exceptionally with no mesoscopic chemical rate modulation!



Three phenomena, likely inducing mesoscopic structuring effects and associated LER contributions with several examples for the resist films are the subjects of the proposed talk:

- Marangoni-Bernard instability in liquid resist films due to solvent evaporation (Spin and SB)
- Stress-induced interfacial structuring at the line edge due to differences in properties of protected and deprotected phases and *T~Tg* (PEB)
- Thermo-chemical patterning at the dissolution interface due to chemical activity (Develop)

Being not sensitive to conventional shot noise parameters, these contributions appear as “LER fundamental limit”. Prevailing over CAR effects at the best CAR performance, and thus masking them, mesostructuring strongly complicates progress in LER improvement.

Considering LER we should be concerned about Mesoscopic Structuring (M-S)!
Identification and suppression of Meso-Structuring effects at various steps of the litho sequence is a MUST!