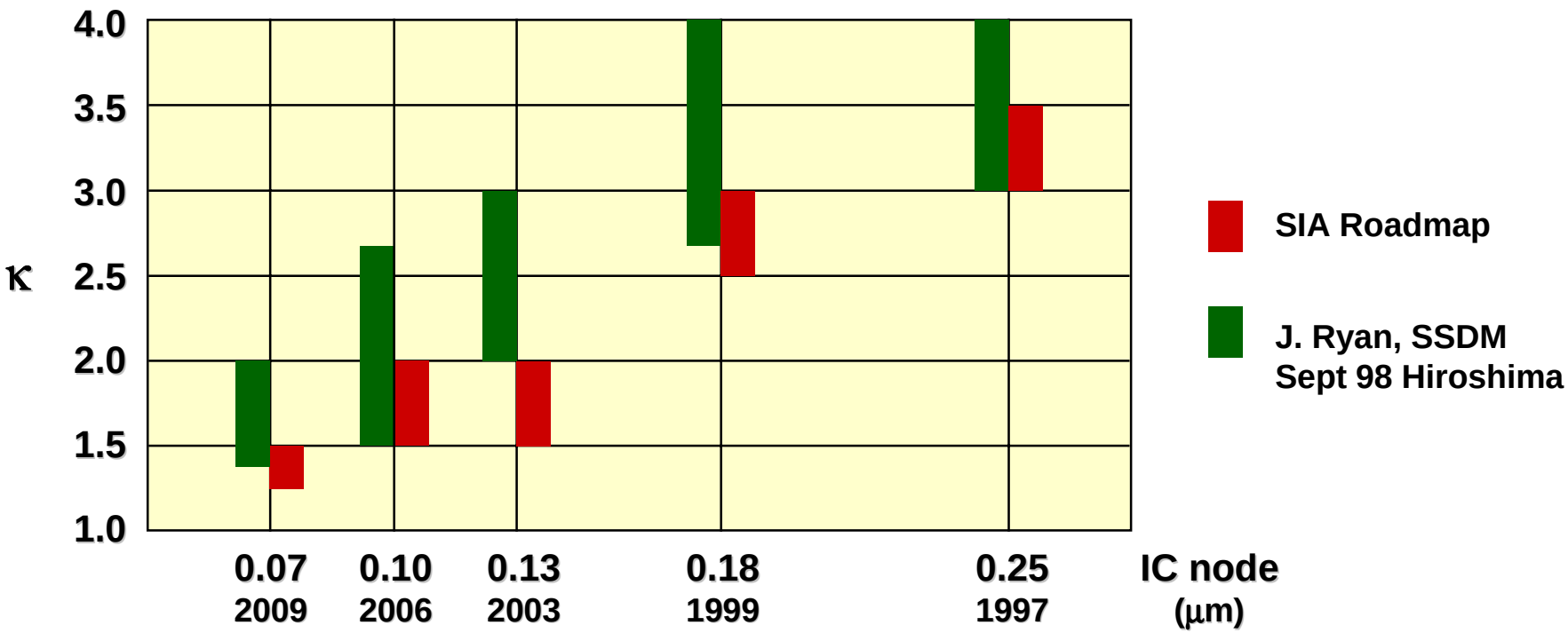
# SIA Roadmap vs Reality

**"For 0.18μm … logic processes,
companies are using inorganic low-κ dielectrics,
predominantly fluorinated oxide (FSG),
but also, hydrogen silsesquioxane (HSQ)."**

**Semiconductor International Jan 1999.**



# Low κ Possibilities

**Table 1. Likely Low-k Materials for ULSI Interconnects**

| Dielectric | Dielectric constant (k) | Glass transition temperature (Tg)(°C) | Refractive index | Water absorption (%) | Stress (MPa) | Gap fill (μm) | Cure temperature (°C) | Weight loss (%wt) at 450°C |
|---|---|---|---|---|---|---|---|---|
| FSG (silicon oxyfluoride, $Si_xOF_y$) | 3.4-4.1 | >800 | 1.42 | <1.5 | -130 | <0.35 | no issue | none |
| HSQ (hydrogen silsesquioxane) | 2.9 | >500 | 1.37 | <0.5 | 70-80 | <0.10 | 350-450 | <3 |
| Nanoporous silica | 1.3-2.5 | >500 | 1.15 | TBD | 0 | <0.25 | 400 | none |
| Fluorinated polyimide | 2.6-2.9 | >400 | ΔRI >0.15(ai) | 1.5 | 2 | <0.5 | 350 | <0.1 |
| Poly(arylene) ether | 2.6-2.8 | 260-450 | 1.67 | <0.4 | 60 | <0.15 | 375-425 | <1.0 |
| Parylene AF4 (aliphatic tetrafluorinated poly-p-xylylene) | 2.5 | $T_{melt}$>510 | 1.548 ΔRI >0.09(ai) | | 100 | 0.18 | 420-450 | 0.5 |
| PTFE (polytetrafluoro-ethylene) | 1.9 | ~100 | 1.34 | <0.01 | 25-27 | <0.30 | 360-390 | 0.8 |
| DVS-BCB (divinyl siloxane bis-benzocyclobutene) | 2.65 | >350 | 1.561 | <0.2 | 30-35 | <0.22 | 300 | <1.0 |
| Aromatic hydrocarbon | 2.65 | >490 | 1.628 | <0.25 | 55-60 | <0.05 | 400-450 | <1.0 |
| Hybrid-silsesquioxanes | <3.0 | $T_{melt}$>250 | 1.58 | 0 | 30-40 | <0.1 | 450 | 6 |

Organic ☐ Inorganic ☐

# Remaining Low κ Candidates

**Inorganic vs. Organic** **F vs. no F** **Porous vs. Non-porous** **CVD vs. Spin-on**
**Hybrids**

| Material | Technique | Trade Name | Company |
|---|---|---|---|
| $F_xSiO_y$ | CVD | | |
| HSQ | Spin-on | Flowable Oxide | Dow Corning<br>Allied Signal |
| Nanoporous Si | Spin-on | Nanoglass | Allied Signal |
| F-polyimide | Spin-on | | |
| Poly(arylene) ether | Spin-on | FLARE<br>VELOX | Allied Signal<br>Schumacher |
| Parylene | CVD | | Novellus<br>Watkins Johnson |
| Aromatic hydrocarbon | Spin-on | SiLK | Dow |
| PTFE | Spin-on | Speedfilm | Gore |
| DVS-BCB | Spin-on | | Dow |
| Hybrid SQ's | Spin-on | MSQ | Dow Corning |
| Amorphous FC, HFC | PECVD | | IBM, NEC<br>Novellus, HP |
| | CVD | Black Diamond | Applied Materials |