



Applied Producer[®] Black Diamond[™] 3 with Nanocure[™] 3 Systems

Applied Producer Black Diamond 3 extends Applied's leadership in nano-porous low- κ dielectric technology established through its Black Diamond ($\kappa\sim 3$) film for 90/65nm copper/low- κ interconnects and Black Diamond II ($\kappa\sim 2.5$) for the 45/32nm nodes. Ultra-low- κ (ULK) Black Diamond 3 with Nanocure 3 UV ($\kappa\sim 2.2$) enables scaling of logic devices to 22nm and below.

As semiconductor devices scale down, the ability to increase device speed is significantly affected by the dielectric constant (κ) of the insulating material (dielectric) between the copper interconnects, which must scale down correspondingly. Increasing the porosity of the dielectric helps reduce its κ value, but also renders the film susceptible to downstream plasma damage or physical damage during packaging steps. This challenge has been effectively managed using a two-step process, making nano-porous low- κ films the standard inter-metal dielectrics.

First, plasma-enhanced chemical vapor deposition creates a nano-composite consisting of an organo-silicate glass backbone with a thermally labile (alterable) organic phase that partially defines the porosity that affects the film's ultimate dielectric constant. Second, an ultraviolet (UV) cure is applied to the film to remove the labile phase (inducing the desired porosity), and restructure the remaining matrix to enhance backbone structure and modify film composition.

As porosity increases, so does the film's fragility. Hence, achieving ULK film ($\kappa\sim 2.2$) for scaling to 22nm and below requires actual re-engineering of the dielectric's composition and structure to strengthen its ability to maintain required mechanical properties (hardness and elastic modulus) during subsequent plasma

etch, photoresist ash, wet clean, chemical-mechanical planarization, and packaging processes.

Black Diamond 3 uses a new organo-silane precursor to achieve the requisite re-engineered matrix to optimize film composition, mechanical strength, and chemical resistance. Besides superior physical film properties, the new chemistry can be tuned to deliver a wide range of films with dielectric constants from as low as $\kappa\sim 2.0$ up to $\kappa\sim 2.5$, allowing users to adopt Black Diamond 3 for today's production and extend it to future nodes.

In addition to re-engineering the dielectric itself, implementing ULK nano-porous film has required improvements in the curing process and hardware to ensure high device yield.

Nanocure 3 leverages Applied's Nanocure DSS+ technology—the only curing process in production for porous low- κ films—and enhances it with newly designed optical and chamber components plus real-time UV intensity monitoring that deliver improved yields through industry-leading curing uniformity (shrinkage, hardness, modulus, and κ value), low defectivity, and higher productivity.

The Black Diamond 3 and Nanocure 3 processes run on the production-proven Producer platform. With its Twin Chamber[®] architecture, the Producer platform enables simultaneous processing of up to six wafers for superior productivity.