

# SEMATECH Engineers Develop Colorful Testing Device to Ease High-k/Metal Search

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SEMATECH engineers have developed an eye-catching test device that allows semiconductor technologists to measure the important electrical characteristic of work function on a single wafer, saving time and increasing accuracy. The device is a specially processed wafer called a terraced oxide substrate, but more humorously dubbed "the wedding cake" by developers within SEMATECH's Front End Processes (FEP) Division. It contains a staircase-like pattern of oxide thicknesses - typically ranging in depth from 20 to 100 angstroms - in a series of four wide, concentric circles. A high-k/metal stack then can be deposited on

the entire wafer, after which the work function can be measured on the resulting collection of oxide-and-metal stacks. Work function pertains to the ability to turn a transistor on and off, and is critical to gate functionality.

“We now have a markedly more accurate way to measure work function on a single wafer,” said Larry Larson, FEP associate director. “You can achieve a process uniformity on a single wafer that you can't across several wafers, because with one wafer, the process remains the same across the oxide layers. This represents a big breakthrough in measuring material characteristics for candidate metals.”

Larson explained that work function measurements previously had to be performed across a set of different wafers, which can contain unwanted variations in oxide charges due to minor process variations. This approach provides less useful metrics because the inconsistencies between the different wafers can affect the work function measurements themselves.

Seeking a better methodology, SEMATECH engineers wrote a recipe program for a spin processor etcher to produce a terraced, silicon-dioxide wafer whose depths can be varied in ranges as low as 10 Å to 50 Å, but which typically are higher. Magnified and viewed from the side, these terraces suggest a stacked cake topped by a central tower. And when the oxide depths are made especially thick (1000Å to 4000Å), the wafer surface takes on a rainbow pattern that resembles a multi-colored bull's-eye target.

The ensuing “standard work function monitor structure” was provided to SEMATECH member companies in mid-2004, and made public at an industry conference in December. Larson said the device will ease engineers' search for a high-k gate metal that will mimic the ability of silicon to be tuned to two different work functions, which are needed to

accommodate the negative and positive channels in electrical circuitry.

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