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Shorter dwell times, higher process temperatures, and compatibility with high-k metal gate structures enable device manufacturers to achieve increased junction activation and reduced leakage while at the same time minimizing wafer deformation related to higher germanium content structures.

Ultratech LSA report

Benefits of Ultratech Laser Spike Annealing in 32nm Wafer Processing Demonstrated

Shorter Dwell Times and Higher Peak Temperatures Improve Device Performance and Reduce Defects

Device manufacturers using Ultratech's LSA100A Laser Processing tool to form ultrashallow junctions at 65 and 45 nanometer nodes are finding that the LSA offers proven extendibility down to 32nm and below. Two distinct advantages over other tools have been established for 32nm: the capability to shorten dwell times to 275 microseconds and the compatibility of LSA with high-k metal gate structures.

LSA 100A's Shorter Dwell Time: 275 Microseconds

The LSA100A has extended its capability to scan at a reduced dwell time of 275 microseconds with a maximum peak temperature of 1350˚C. This enhancement, which includes a new

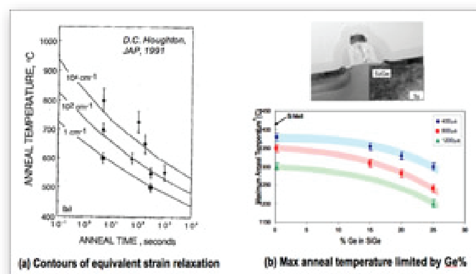

Figure 1. The LSA's shorter dwell times enable higher annealing temperatures, which reduce strain relaxation (a) and dislocation formation in high-concentration SiGe (b).

optical configuration, is now available as a field upgrade. Customers can also evaluate this capability using the Ultratech demo lab.

The advantages of shorter dwell times are well established. Shorter dwell times minimize strain relaxation of strain engineering processes and materials, especially SiGe. As higher concentrations of germanium are utilized (>30%) in SiGe at the 32nm node, maximum annealing temperature without slip (dislocation) decreases. (Please see Figure 1.) The LSA100A's shorter dwell times relax strain less than competing tools and thus permit higher peak temperatures without creating more defects. The result is higher dopant activation and improved I-on/I-off transistor characteristics.

"Shorter dwell times create more abrupt junctions with minimal diffusion and less leakage," explains Peter Lee, Director of LSA Product Marketing at Ultratech. "When dwell time is shorter, low sheet resistance can be achieved with reduced dopant diffusion, resulting in the downward shift of the Rs (sheet resistance)–xj (junction depth) curve." The shorter processing times also reduce wafer warpage and downstream lithography misalignment. " Explains Peter, "Contact-to-gate misalignment is very sensitive to wafer warpage. Customers have seen that lowering the dwell time for advanced anneal processes directly resolves misalignment problems."

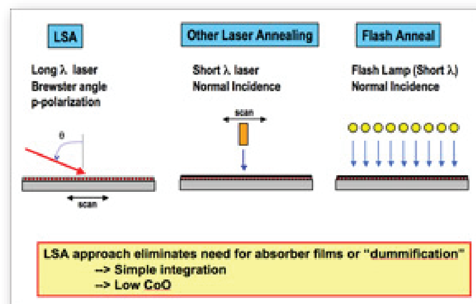

Figure 2. A competitive comparison of advanced annealing technologies shows how Ultratech's LSA tool minimizes pattern effect.

LSA Compatibility with Hi-K Metal Gate Structures

Studies have shown that the LSA100A has been successfully integrated with high-k metal gate structures processed with both gate-first and gate-last integration schemes. Many advanced logic manufacturers will use high-k metal gate structures starting at the 32nm technology node. The reflectance of advanced anneal radiation from metal gate materials will generally be higher than for polysilicon gates, and pattern effect will be a more serious challenge. However, Ultratech's unique

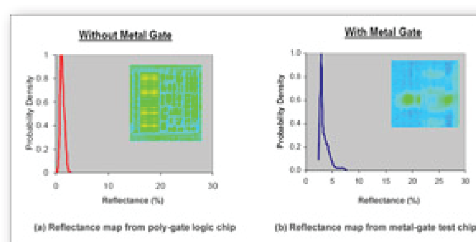

Figure 3. The LSA produces only slightly higher reflectance on a metal-gate die than a non-metal-gate die and eliminates the need for additional absorption layers.

and patented use of long-wavelength (10.6 µm) laser light with p-polarization and unique angles of incidence of the laser onto the wafer plane results in one of the major advantages of LSA: maximum absorption of laser energy and minimal pattern effects as compared to competing flash and laser-based technologies. (Please see Figure 2.) This LSA advantage will become more prominent in 32nm high-k metal-gate generation, with the majority of manufactures using the gate-first method.

As Figure 3 shows, using the LSA 100A tool, the average measured reflectance of a metal-gate device is less than 5 percent, which is comparable to that achieved with LSA on a polysilicon-gate device. The resulting reduced pattern effect gives the LSA100A a substantial technical advantage over competing tools that operate at shorter wavelengths, such as those utilizing flash lamps, especially in high-k metal gate structures. By eliminating the need for additional absorption layers, the LSA 100A allows customers to improve yield and reduce their cost-of-ownership.

Critical In Situ LSA Metrology for 32nm

As customers transition 32nm technology into production, real-time process control will be critical for increasing parametric yield and preventing wafer scrap through automated interdiction. The LSA100A features a closed-loop temperature control system that measures and controls the peak tempera-

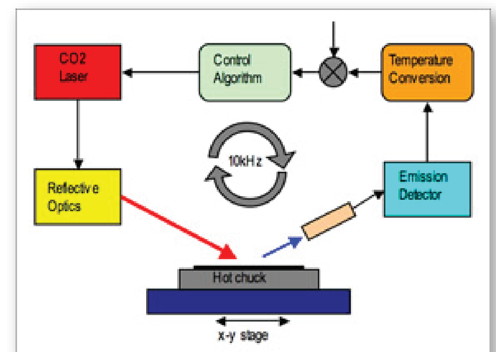

Figure 4. The LSA's within-wafer temperature control scheme measures and controls the peak temperature of device wafers in real time, which allows more uniform and repeatable device performance.

ture of device wafers in real time at a rate of 10kHz (see Figure 4). This state-of-the-art metrology system allows more uniform and repeatable device performance and also allows the factory automation system to halt the process if unacceptable process excursions occur.

In summary, Ultratech's advanced LSA 100 technology offers customers maximum process flexibility. Comments Peter Lee, "As device performance becomes increasingly dependent on efficient dopant activation and defect reduction, micro-second anneal temperature uniformity is crucial to ensure high yield with minimal pattern effect. The LSA 100A is well positioned for annealing of advanced devices at the 32 nanometer node and below because it is uniquely able to adjust dwell times, beam shape, and output power so as to permit maximum process flexibility. The LSA 100A's localized heating effect makes it uniquely suitable for ultrashallow junction formation."

For More Information

For more information on Ultratech's LSA tools and technology, including technical papers, please go to www.ultratech.com.