Beyond Thickness: Using Picosecond Ultrasonic Technology for SiCr Process Control in BCD Devices

By Huayuan Li, Alex Hong, Johnny Mu, and Timothy Kryman
Onto Innovation

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Building a bipolar-CMOS-DMOS (BCD) device is one challenge; maintaining the material consistency required for reliable high-volume manufacturing (HVM) is another. In fact, achieving consistent device performance starts long before the first electrical test.

From the safety systems in today's vehicles to the power-efficient electronics in consumer devices, BCD technology supports applications where analog accuracy, digital control, and power management must work together reliably. As BCD technology serves more demanding end markets, manufacturers face increasing pressure to maintain tight process control, high yield, and long-term reliability at scale.

In the first installment of this series, we discussed how SiCr film thickness and uniformity influence resistance, analog accuracy, and long-term reliability, making deposition control essential for HVM. To address these challenges, we introduced picosecond ultrasonic technology, a non-contact, non-destructive metrology technique that uses laser-generated acoustic waves to measure thin film thickness with precision. By analyzing acoustic echoes within the SiCr layer, manufacturers can measure film thickness on production wafers and monitor deposition performance using a first-principles approach.

While thickness control is a critical component of SiCr process optimization, it represents only part of the process control picture for BCD devices.

Films with similar thickness values can exhibit meaningful differences in microstructure, density, composition, and surface morphology. These variations can influence key electrical characteristics such as temperature coefficient of resistance (TCR), resistor matching, and long-term stability, creating performance differences that may not be detected through thickness measurements alone. Because these changes can be difficult to detect during deposition, manufacturers need additional visibility beyond thickness metrology. Early detection of these variations helps engineers identify excursions before they affect downstream electrical performance.

In this installment, we examine how picosecond ultrasonic technology can provide that additional insight simultaneously. By leveraging reflectivity data alongside thickness measurements, the same picosecond ultrasonic technology platform can help flag process excursions, monitor gas flow-related variation during sputtering, and provide complementary insight into SiCr film quality.

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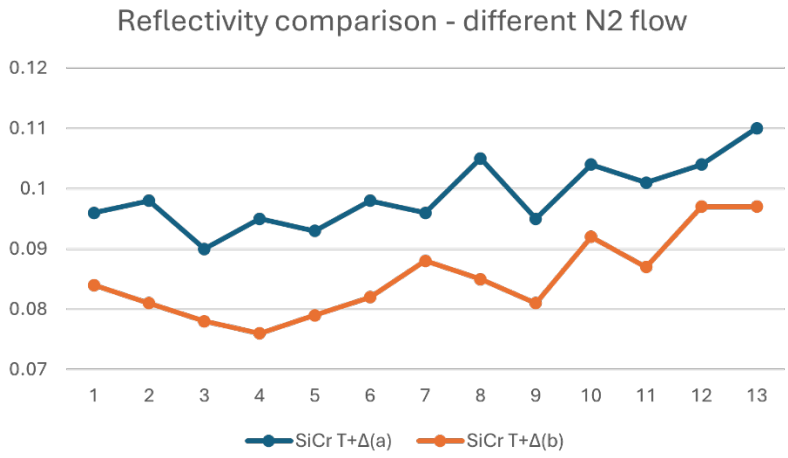
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Film quality

In addition to acoustic data used for thickness measurement, the probe signal provides simultaneous reflectivity data. Reflectivity can serve as a qualitative indicator of SiCr surface morphology and roughness. This helps engineers optimize the process and flag excursions.

During SiCr sputtering, specialty-gas flow can influence film microstructure and stoichiometry, affecting density, composition, and TCR behavior across the wafer. These changes can include differences in features such as grain growth and grain boundary spacing, both of which are known to influence TCR behavior. As a result, wafers with similar thickness measurements can still exhibit differences in electrical behavior. Because such variations may occur even when thickness appears uniform, manufacturers need complementary monitoring to identify process variation before it affects downstream device performance.



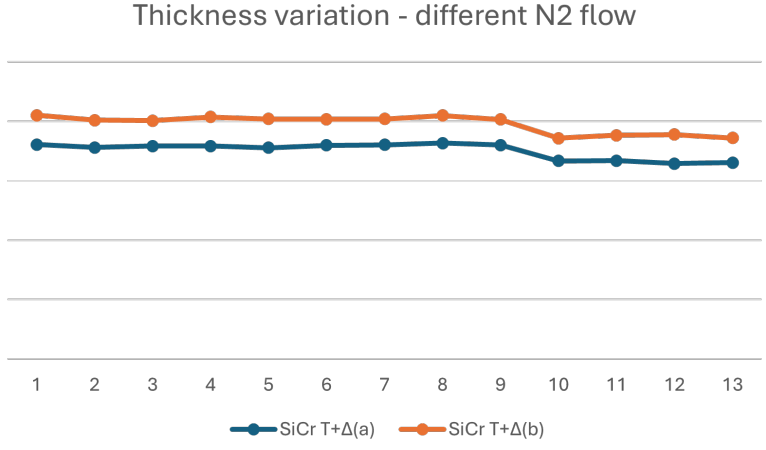


Figure 1. Wafer-level reflectivity (top) and thickness (bottom) for SiCr films produced at two N_2 flow conditions. The films have similar target thicknesses but distinct reflectivity signatures. Orange indicates the lower-flow condition; blue indicates the higher-flow condition.

In the demonstration, engineers collected reflectivity and acoustic data from SiCr wafers processed at two gas-flow conditions. Condition (b) produced higher reflectivity, consistent with a smoother, denser surface, while condition (a) produced lower reflectivity, consistent with increased surface roughness. The SiCr film was also thinner at the higher N_2 flow condition. Because N_2 flow can influence silicide/nitride formation and grain spacing, it can affect both film thickness and reflectivity. Because reflectivity is collected with the acoustic measurement, it adds process information without a separate metrology step. Used as a qualitative indicator, reflectivity can complement thickness measurements and help engineers monitor gas-flow-related deposition variation and flag potential process excursions.

Summary
For BCD manufacturers, thickness alone does not provide the full SiCr process picture. By combining in-line thickness metrology with simultaneous reflectivity measurements, manufacturers can improve visibility into deposition variation and support more consistent resistor performance. With picosecond ultrasonic technology, manufacturers have a powerful, non-destructive tool for monitoring thickness and reflectivity. In doing so, they can gain earlier insight into process variation, support more consistent BCD device manufacturing, and help maintain device performance across automotive, medical, and consumer electronics applications.

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Biography
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