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RESURF Technology Reimagined Enters Marketplace In 150-V Silicon MOSFETs

iDEAL Semiconductor's SuperQ technology has entered full production, with the first products being 150-V MOSFETs. In addition, a family of 200-V MOSFETs is sampling, while 250-V to 400-V MOSFETs are coming soon. This represents a culmination of efforts to commercialize the company's technology, which was launched with some device sampling, two years ago. (See "Semiconductor Technology Pushes Silicon Beyond Its Assumed Limits For Power Devices," How2Power Today, November 2023.)

According to iDEAL Semiconductor, the SuperQ architecture delivers unmatched performance and efficiency in silicon power devices, breaking through silicon's fundamental switching and conduction barriers. It almost doubles the n-conduction region (with up to 95% conduction path utilization) and reduces switching losses by up to 2.1x versus competing devices, says the vendor.

The structure also improves resistance and power losses while maintaining the benefits of silicon, including its ruggedness, high-volume manufacturability, and proven reliability at a 175°C junction rating.

The first product in iDEAL's 150-V MOSFET series, the iS15M7R1S1C, is a 6.4-mΩ MOSFET. It is available immediately in a 5-mm x 6-mm PDFN package. The SMT package includes exposed leads to simplify assembly and improve board-level reliability (Fig. 1).

The 200-V family includes the iS20M6R1S1T, a 6.1-mΩ MOSFET in a 11.5-mm x 9.7-mm TOLL package. This has an $R_{DS(ON)}$ of 6.1 mΩ, which is 10% lower than the current industry leader and 36% lower than the next best competitor in silicon, says the vendor. The company is also sampling 200-V MOSFETs in TOLL, TO-220, D2PAK-7L and PDFN packages.

In addition, 250-V, 300-V and 400-V MOSFET platforms are coming soon—voltage classes underserved by today's silicon technologies, according to the vendor. iDEAL's upcoming devices are designed to deliver dramatically lower resistance than existing solutions.

SuperQ is billed as the first significant advance in silicon MOSFET design in more than a quarter of a century—since the introduction of superjunction MOSFETs by Siemens Semiconductor (now Infineon Technologies) in 1998. (The superjunction (a.k.a. RESURF) architecture was first proposed in 1978, with patents filed in 1980.)

When Siemens Semiconductor introduced the superjunction MOSFET, it applied a charge balancing concept that enables a thinner more heavily doped drift region, leading to a lower $R_{DS(ON)}$ and smaller chip size for a given breakdown voltage (Fig. 2). However, in doing this, its use of alternating p+ and n columns used for charge balancing reduced the area available for conduction by half.

iDEAL Semi's SuperQ device structure restores that conduction area to nearly the full width of the device, replacing the p+ columns in the drift region with thin, charged dielectric layers on the sidewalls of the structure. This achieves a similar effect of charge balancing as in the conventional superjunction structure, but with the charge balancing materials only representing a small portion of the total device structure. The company describes this structure as an asymmetric charge balanced trench.

In SuperQ, these dielectric layers are deposited using atomic layer deposition. Then, proprietary processing is applied to activate some of the dopant in the film, which forms a charge balance region in the epitaxial layer. The dielectric material, which is described as a "proprietary dielectric blend" is part of the company's secret sauce.

In addition to increasing the available conduction area, this device structure enables use of thinner epitaxy (leading to better figure of merit) and higher doping concentration, reducing on-resistance.

SuperQ leverages film materials and tools used in advanced CMOS processes. As the company's white paper explains, "SuperQ is manufactured using a traditional CMOS-like flow suitable for 200-mm and 300-mm wafers. It builds on the innovations in CMOS over the last decades and leverages tools and processes that are commonly found in state-of-the-art 300-mm CMOS Fabs. Though elegant, the SuperQ flow is greatly simplified versus superjunction's epi+implant or trench+refill flow."

Moreover, the process node used to fabricate SuperQ MOSFETs is a mature one—a 0.18-micron process, and there are cost savings associated with that. And then, if processing SuperQ wafers is simpler and less expensive

than for superjunction silicon, we can imagine that it will be potentially even lower in cost when compared with GaN on silicon and certainly silicon carbide.

More information on SuperQ technology and comparisons with silicon, GaN and SiC are provided in the company's white paper, which is linked to below.

"For the past quarter-century, the industry has relied on reduced surface field (RESURF) technologies like superjunction, but these architectures' performance has plateaued. To achieve the necessary gains in power delivery and efficiency, a new architecture is required and that is SuperQ," said Mark Granahan, CEO and co-founder of iDEAL Semiconductor.

Granahan added, "The demand for higher performing power solutions has never been greater. SuperQ will enable emerging critical applications ranging from industrial automation, AI data center and the world's electrification trends. Today iDEAL is announcing new levels of cost times performance for the designer's toolbox at 150 V to 400 V that simply didn't exist."

This innovation is designed for MOSFETs, IGBTs, diodes, power ICs, and even future semiconductor materials, positioning SuperQ as a foundational technology for the next era of power electronics.

iDEAL's silicon power devices are invented, engineered and fabricated in the United States. However, like most semiconductor startups, iDEAL Semiconductor is fabless. The foundry that it works with is Polar Semiconductor in Minnesota.

iDEAL's devices are available in a wide range of industry-standard, drop-in compatible packages, including TO-220, ITO-220, TO-247, D2PAK-3L, D2PAK-7L, DPAK, TOLL, TOLT, and PDFN 5x6. The products are designed for a broad voltage and application spectrum.

To learn more about SuperQ technology, see the white paper, "Science & Engineering at the Atomic Level, A breakthrough makes the world's Electronics energy efficient". For more information on the new devices described here, visit www.idealsemi.com.

Fig 1. iDEAL Semiconductor's SuperQ technology has entered full production, with the first products being 150-V MOSFETs. In addition, a family of 200-V MOSFETs is sampling, while 250-V to 400-V MOSFETs are coming soon.

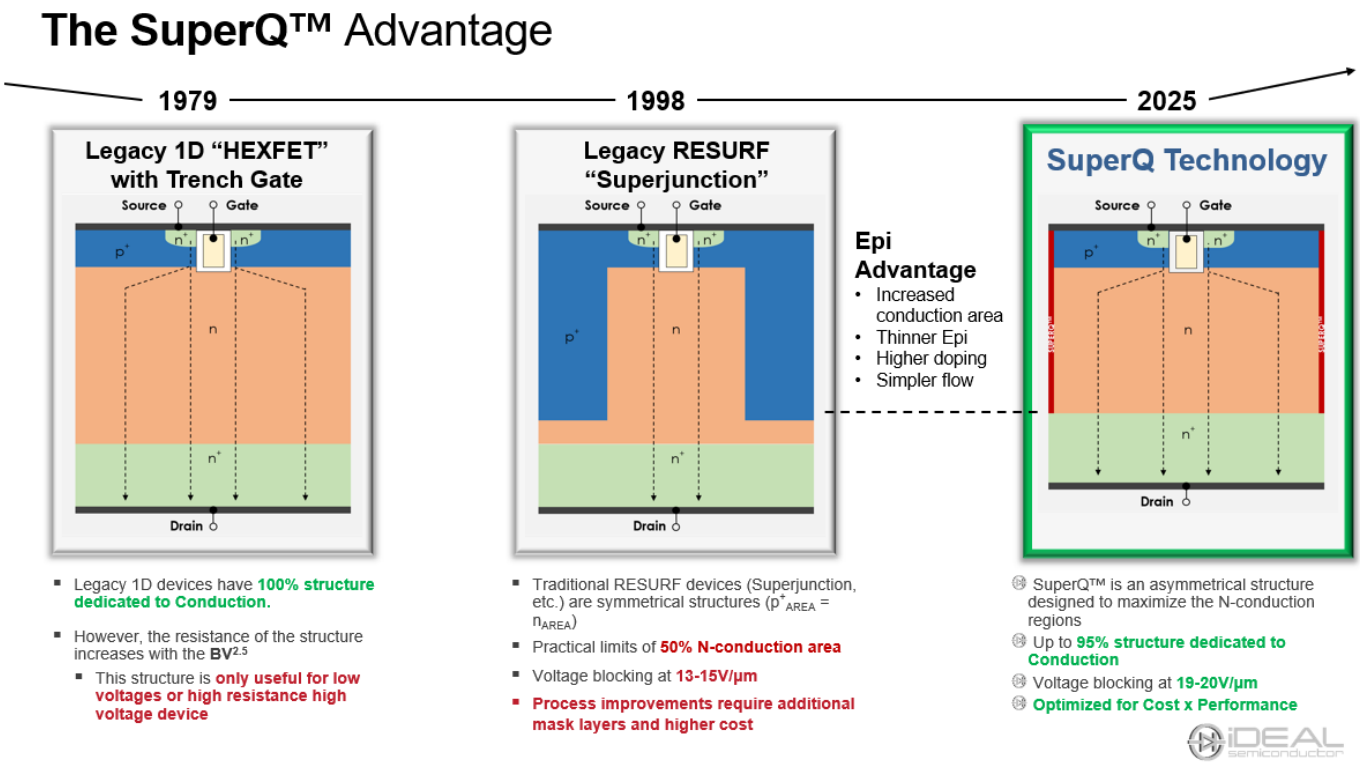

Fig. 2. SuperQ's asymmetric trench charge balancing structure (diagram on the right), represents an evolution in RESURF technology—as first commercialized by Siemens Semiconductor in the late 90s (middle diagram)—that restores the available conduction area available to that more in-line with the original HEXFET MOSFETs introduced by International Rectifier (diagram on left) but with the RESURF advantage of a more highly doped n region.