

Demo Suggests Cascode MOSFET Stacks up Well Against SiC And Si Switches

[Alpha and Omega Semiconductor](#) (AOS) and [SemiSouth Laboratories](#) have jointly demonstrated UniSiC, a 1200-V, 90-mΩ MOSFET in a TO-262 package. The device, which the companies describe as revolutionary, is intended to meet the growing need for energy-efficient switching devices for high-performance power conversion applications in the alternative energy, industrial and consumer segments. According to the company, the dramatic reduction in form factor and figures-of-merit put this 1200-V MOSFET device in a class by itself.

The UniSiC MOSFET provides extremely low $R_{ds(on)}$ and gate charge Q_g , an excellent body diode with virtually no stored charge and a low diode-forward-voltage drop. The device may be used similar to a conventional MOSFET or IGBT, with standard gate drives and is engineered so it can be switched over a wide speed range—as fast as a superjunction MOSFET or as slow as an IGBT. The device is claimed to have characteristics that are far superior to existing IGBTs, silicon power MOSFETs or even the best competitive SiC 1200-V MOSFET.

Table 1 compares key parameters of AOS' UniSiC stack-cascode device with similarly rated alternatives such as one of Cree's 1200-V SiC MOSFETs and a projected 1200-V silicon superjunction device. The photo in the figure then compares the die sizes of the UniSiC stack-cascode device with the SiC MOSFET and a 1200-V IGBT with a co-packaged diode. The small die size shows the tremendous potential this device creates for future miniaturization of power circuits given how much it cuts conduction and switching losses.

The UniSiC device is formed by stacking a specially designed low-voltage silicon MOSFET atop a normally-on SiC JFET provided by SemiSouth. The low-voltage MOSFET is specially engineered to allow optimal operation of the composite device with clean switching, low $R_{ds(on)}$, gate charge and superb diode characteristics. It is intended to provide great ease of use, working with standard drive circuitry, and drastically improving circuit efficiencies over the whole range of load current.

"Using the superb characteristics of SiC JFETs for high-voltage applications, and solving the switching problems that have plagued cascode devices in the past, AOS is in a position to offer the power electronics community a dream switch," says Dr. Anup Bhalla, vice president of High-Voltage Discretes at AOS. When asked about the technical challenges overcome in developing this device, Bhalla elaborates, saying "Cascode devices are notorious for switching off too fast with a lot of ringing. We have addressed that by proprietary techniques, one of which is the [achievement of] reduced parasitics in the connections between the SiC JFET and LV MOSFET; an outcome of the intimate stacking arrangement."

As a result, Bhalla says, "The devices can be used like conventional discrete IGBTs and FETs using the same gate drives, allowing the user to realize huge efficiency gains without too much re-engineering."

The cascode device also overcomes limitations of existing SiC MOSFETs as Bhalla describes when asked to explain the performance advantages highlighted in the table.

"The Cree MOSFET suffers a lot of R_{ds} degradation from poor channel mobility. This requires them to use a larger chip area to achieve a certain R_{ds} . The large number of paralleled channels leads to high Q_g . This does not plague the cascode; the gate charge of the cascode is dictated by the small low voltage series MOSFET, making the composite device really low in Q_g ," says Bhalla. "Just as important is the fact that the Cree MOSFET cannot be driven by a 0 to 15-V gate drive, while our UniSiC cascode can. Finally, there is a big difference in the forward drop of the body diode. In the Cree device, the 3.5-V drop is simply the junction drop of the body junction. In the UniSiC, this is bypassed, because the body diode consists of the 0.7-V low voltage Si PN junction in series with the JFET resistor. The only stored charge in the UniSiC diode is from the 30-V MOSFET, and it is very small."

"SemiSouth is excited to see the performance achieved by AOS using our SiC power JFET die. First released in 2008, we have seen our JFET products gain rapid adoption in the market, and this first-ever stack-cascode demonstration from AOS really takes the performance and ease of use to the next level," says Dr. Jeff Casady, president and CTO of SemiSouth Laboratories.

According to Bhalla, the new cascode device is not yet sampling to outside customers. A mass production release schedule will be published in the next week or two (in time for APEC 2012.) At the time this article is being posted, a datasheet is not yet available. For more information, see www.aosmd.com.

Table 1: Vendor's comparison of the UniSiC Stack-Cascode MOSFET with a competing SiC MOSFET and a projected 1200-V silicon superjunction device.

Parameters	Test Conditions	CMF20120 (Cree)	Cascode (AOS+SemiSouth)	1200V Si Superjunction FET
Size		4.4 x 4.4 mm	2 x 2.25 mm	7 x 11 mm
BVdss	Id = 100 μ A	1200 V	1200 V	1200 V
Vth	Id = 1mA	2.5V	3.6V	3.0V
Rdson	Vgs = 20 V	80 mΩ	80 mΩ	100 mΩ
Rdson	Vgs = 10V	>200 Ω	80 m Ω	100 m Ω
Qgs	Vds = 400 V, Id = 20 A	26 nC	4.4 nC	70 nC
Qgd	Vds = 400V, Id = 20 A	29 nC	3.6 nC	125 nC
Qg(19V)	Vds = 400V, Id = 20 A	80 nC	22.6 nC	350 nC
Rds(20V)*Qg(19V)		6.4 Ω *nC	1.8 Ω *nC	35 m Ω *nC
VFSD	IF = 10 A	3.5 V	1.5 V	0.9 V
Qrr	Vds = 400 V, Id = 20 A, di/dt = 500 A/ μ s, Vgs = 0 V	163 nC	151 nC	25000 nC



Figure. Comparison of die sizes for the UniSiC Stack-Cascode MOSFET from Alpha and Omega, a SiC MOSFET, and an IGBT with co-packaged fast recovery diode.