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SwissSEM Technologies AG

Optimizing Turn-off Controllability of Micropattern Trench IGBTs for 900 A ED Type Modules

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Introduction

- Switching fast IGBTs at high stray inductance can induce overvoltage (Fig 1. orange).
- The IGBT can be tuned on device-level for slower (Fig 1. black).
- Improved technology can also reduce overvoltage while keeping low turn-off losses (Fig 1. purple).

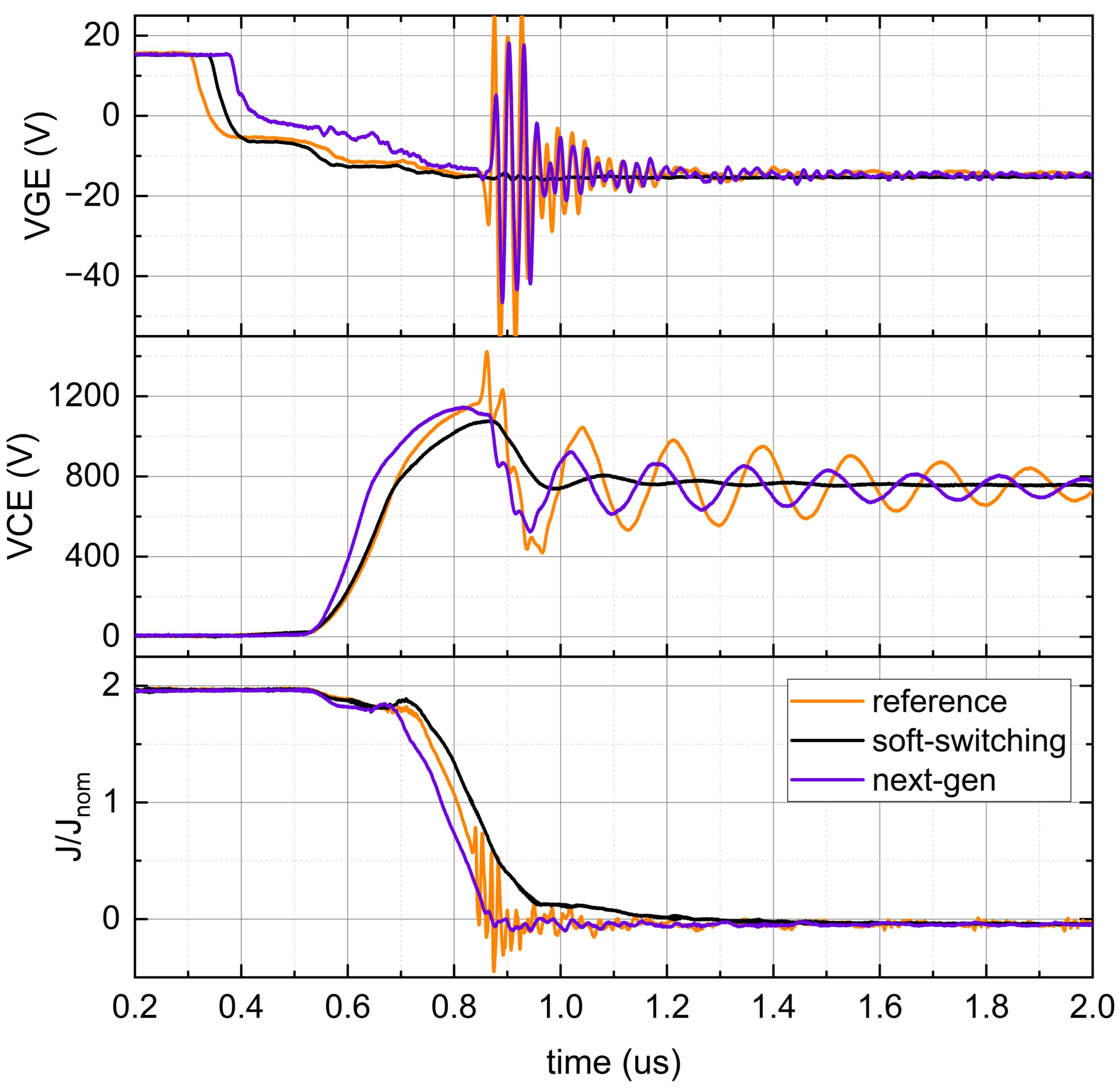

Fig. 1: Example of turn-off waveforms at elevated stray inductance.

Controllability

- To reduce overvoltage of a given IGBT, $R_{G,off}$ can be increased and switching slowed.
- The response of peak overvoltage ($V_{CE,max}$) vs switching delay time ($t_{d,off}$) is called controllability.
- With a controllable IGBT, more applications can be serviced by a single device.

Experiment

- Different 1200 V IGBT designs shown in Table 1 have been assembled and tested.
- The switching speed can be tuned with the anode efficiency, determined by buffer & anode doses.
- The controllability can be improved by reducing carrier confinement, which also increases conduction losses ($V_{CE,sat}$).
- Next-gen device features trench mesa and pitch scaling (Fig. 2)

Table 1: Fabricated and tested samples.

Device	Anode efficiency	Carrier confinement	Trench Mesa
Soft Switching	High	High	std
Controllable	High	Low	std
Fast-switching	Low	High	std
Next-gen	Medium	Low	reduced

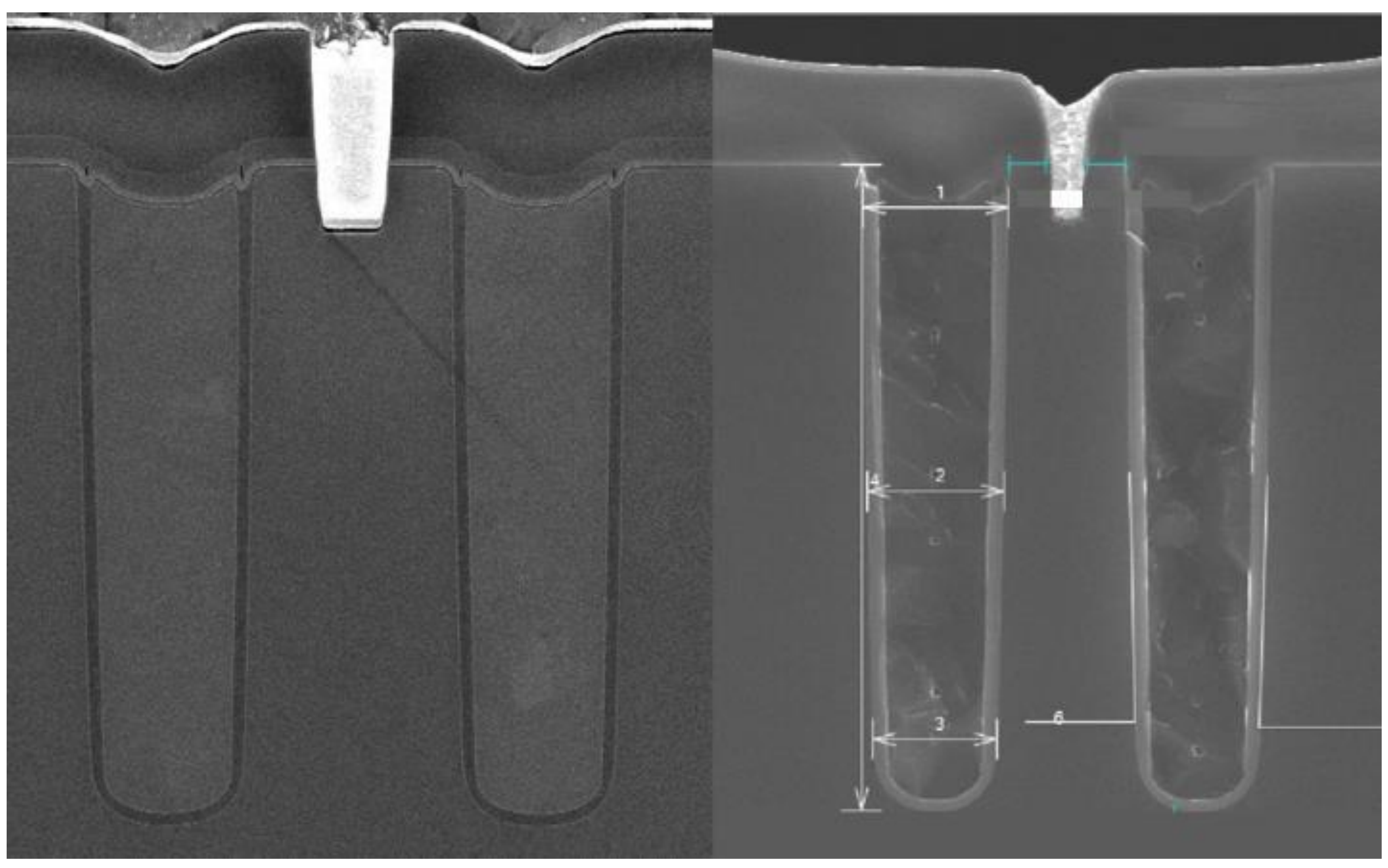

Fig. 2: Example of scaled trench mesa in the right SEM image. Both images are in the same scale.

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Results

- The technology curve at 175 °C is shown in Fig. 3
- The controllability plot is shown in Fig. 4. The individual points on a curve represent different $R_{G,off}$ values.
- Decreased carrier confinement leads to a degradation in the technology curve, but improved controllability.

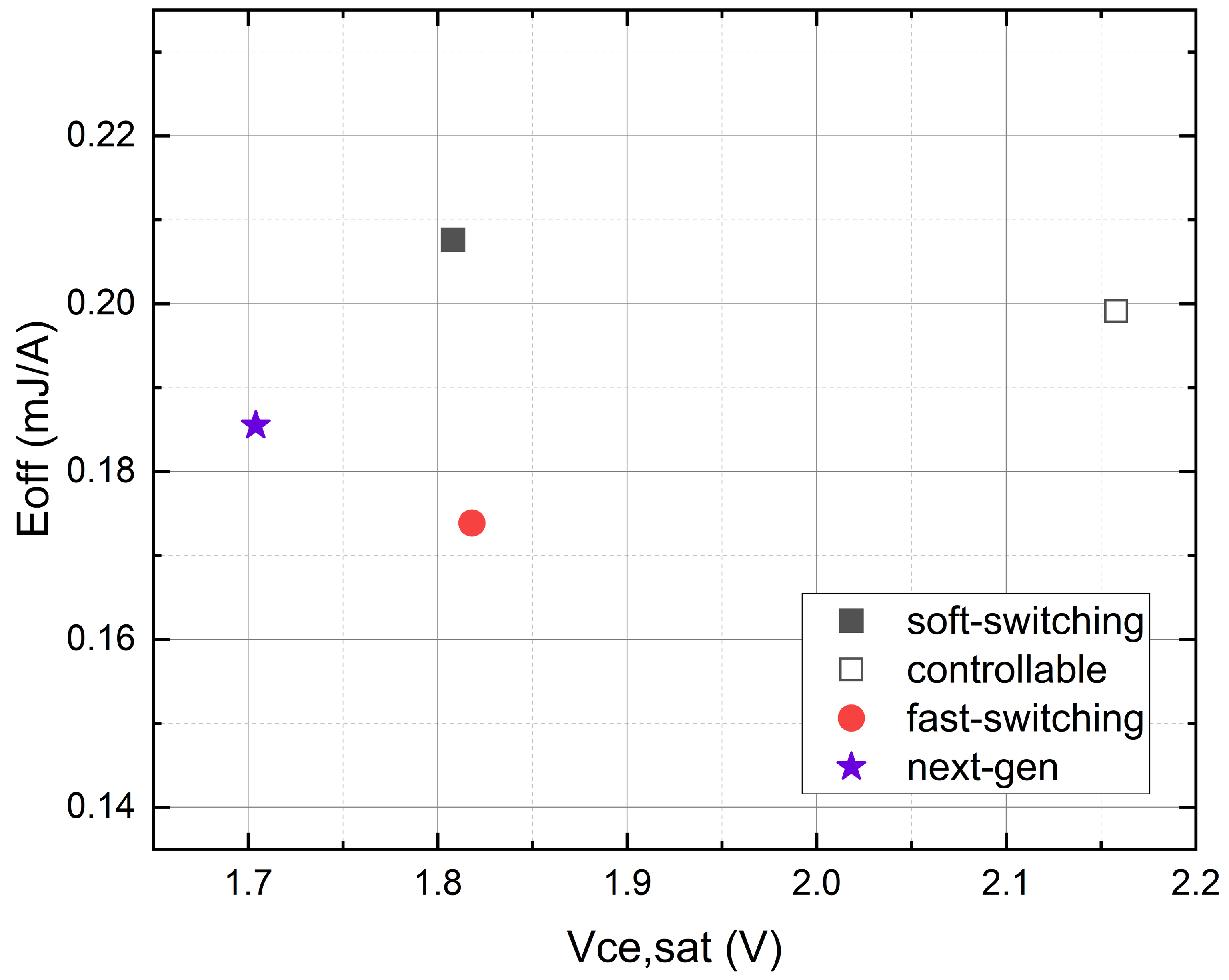

Fig. 3: Technology curve of tested samples at 175 °C and nominal current density

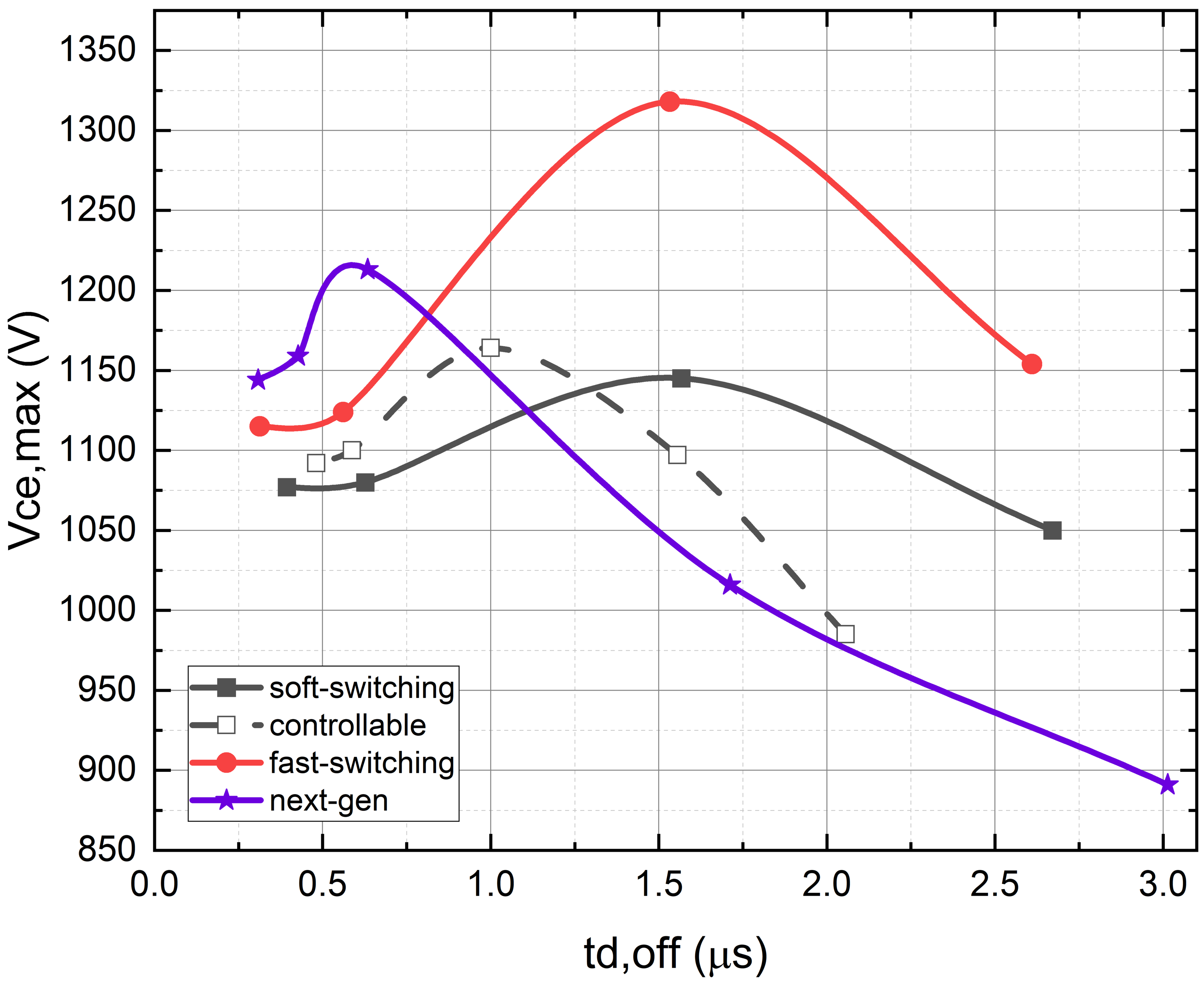

Fig. 4: Controllability graph at 25 °C and elevated stray inductance and voltage levels

ED-type modules

- The soft-switching and next-gen chips are assembled in 1200 V ED-type modules (Fig. 5), with 600 A and 900 A rating, respectively
- The 600 A soft-switching module is specifically developed for 3-level inverters, such as (A)NPC for solar and wind.
- The 900 A module offers excellent performance in 2-level inverters for e-mobility, but can also be used in high stray inductance circuits thanks to the controllability.
- Both modules passed RBSOA at 900 V, 175°C, and double nominal current (Fig. 6)

Fig. 5: SwissSEM ED-type module

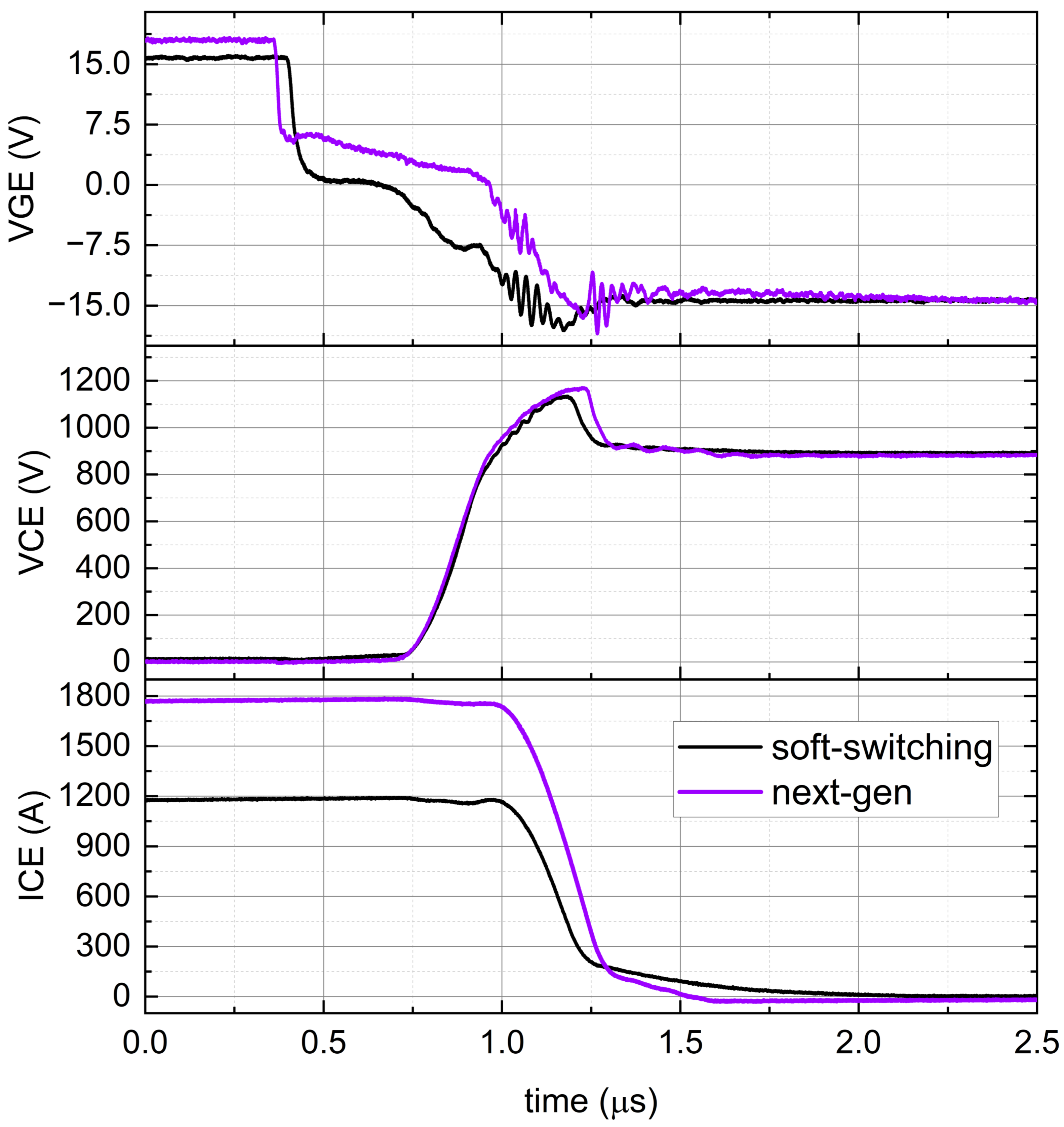

Fig. 6: RBSOA waveforms of the 600 A soft-switching and the 900 A next-gen modules.