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ABSTRACT:

High-Temperature Solar Cells

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High-temperature solar cells and thermal energy converters are possible by exploiting hybrid mechanisms, such as thermionic-thermoelectric generation[1], thermionic-photovoltaic conversion [2, 3], and photon-enhanced thermionic emission (PETE) concept, which represent novel and promisingly efficient (>50%) mechanisms for the exploitation of concentrated sunlight.

Ultrashort laser pulses can tailor the optical properties of concentrated sunlight absorbers by maximizing solar absorption and selectivity thanks to surface periodic nanostructures [4]. Solar thermionic energy converters with surface nanotextured surface have already been demonstrated to enhance the selective absorption in prototypes based on nanodiamond emitters. More advanced PETE converters rely on the concept that engineered semiconductor photocathodes can provide an efficient electron emission, obtained by a synergistic combination of photogeneration and thermionic emission. Surface nanotexturing induced by ultrashort laser treatments can also tailor the electronic properties of semiconductors, so that PETE cathodes can be drastically enhanced in terms of photosensitivity even to sub-bandgap radiation.

Converters with black diamond PETE and nanodiamond-on-silicon cathodes are under development. Results under a high-flux solar simulator are reported and discussed by demonstrating for the first time the PETE conversion at temperatures from 300 to 525 °C.

[1] D. M. Trucchi et al., "*Solar Thermionic-Thermoelectric Generator (ST2G): Concept, Materials Engineering, and Prototype Demonstration*", Advanced Energy Materials, vol. 8, no. 32, 2018.

[2] A. Bellucci, et al., "*A Three-Terminal Hybrid Thermionic-Photovoltaic Energy Converter*", Advanced Energy Materials, vol. 12, no. 20, 2022.
[3] A. Bellucci et al., "*Photovoltaic Anodes for Enhanced Thermionic Energy Conversion*", ACS Energy Letters, vol. 5, no. 5, pp. 1364-1370, 2020.
[4] P. Calvani et al., "*Black diamond for solar energy conversion*", Carbon, vol. 105, pp. 401-407, 2016 2016.