Laser processing of SiC: From graphene-coated SiC particles to 3D graphene froths

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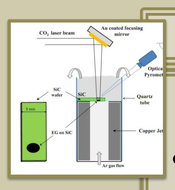
Motivation

- We explore the feasibility of laser-assisted graphitization of micron sized SiC particles.
- It is demonstrated that laser-mediated SiC decomposition, at nearly ambient conditions, can result in a manifold of graphene structures e.g. SiC particles covered by few-layer epitaxial graphene up to highly porous graphene-like structures (froth morphology).
- SiC particles coated by few-layer graphene films are considered for applications in macro- and nano-electromechanical systems owing to their very high electrical conductivity.
- The enhanced mechanical properties of graphene-coated SiC particles may be suitable for body armor applications.

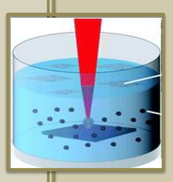
Introduction

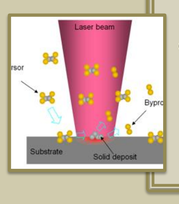
Laser-Assisted Graphene Growth and Processing



Graphene Growth

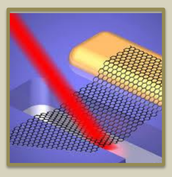
- Epitaxial on SiC
- Ablation of Graphite
- Decomposition of Organic Films
- Laser Exfoliation in Liquids
- Heat source for CVD growth



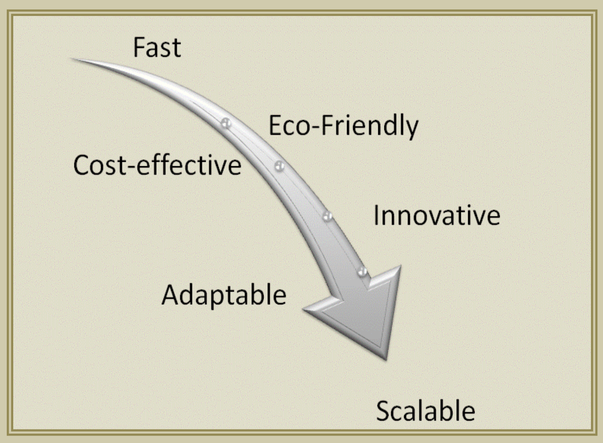


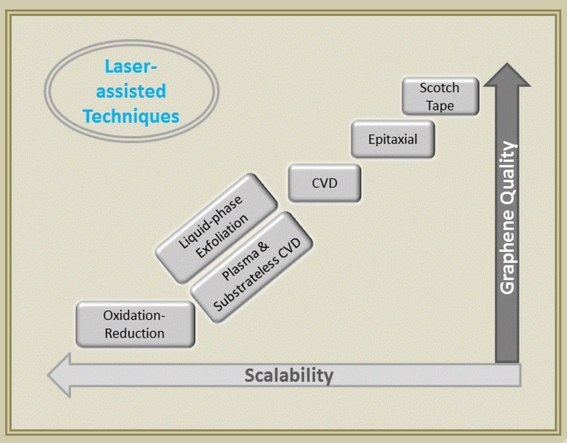
Graphene Processing

- GO Reduction to Graphene
- Laser Thinning of Multilayer Graphene

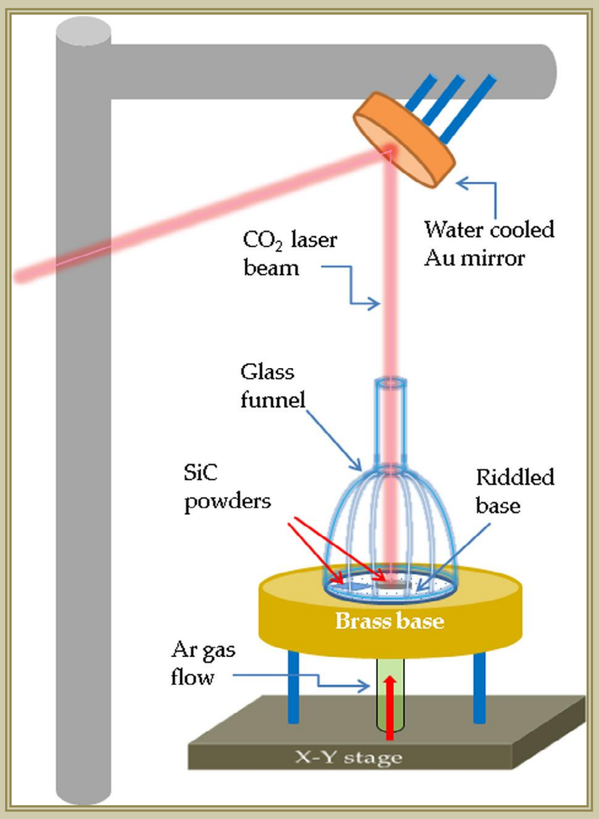


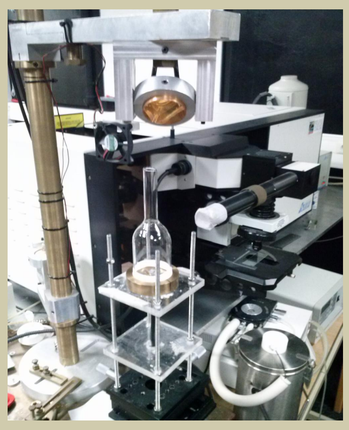
Advantages of Lasers in Graphene production





Experimental



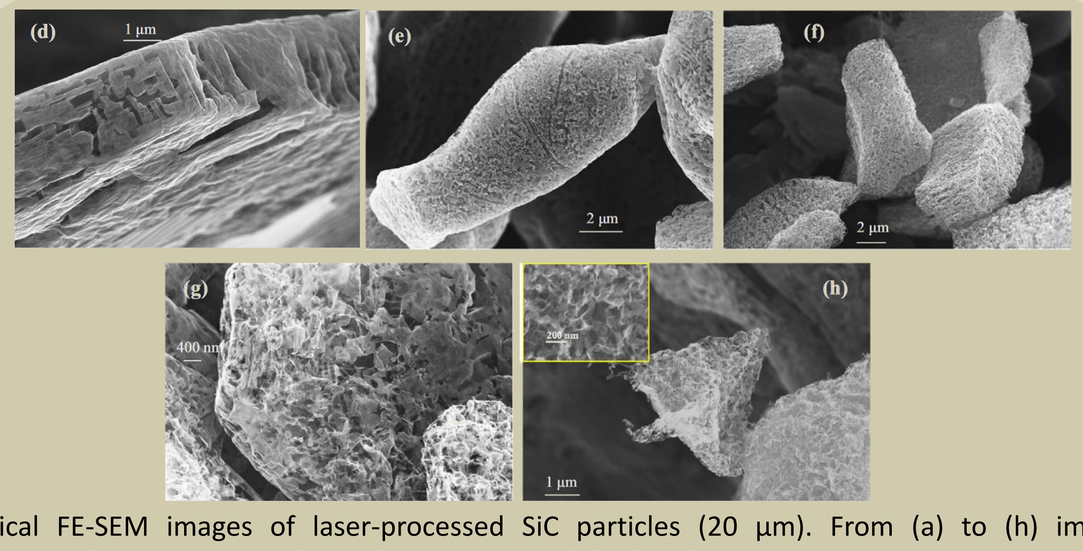


- ✓ α-SiC powders: average particles sizes 2 μm and 20 μm.
- ✓ Laser irradiation took place using a CO_2 laser (10.6 μm) with power levels between 15 and 30% of the maximum power (240 W)
- ✓ Irradiation duration: few seconds
- ✓ Graphitization process at almost ambient conditions (mild flow of shielding Ar gas)

Results

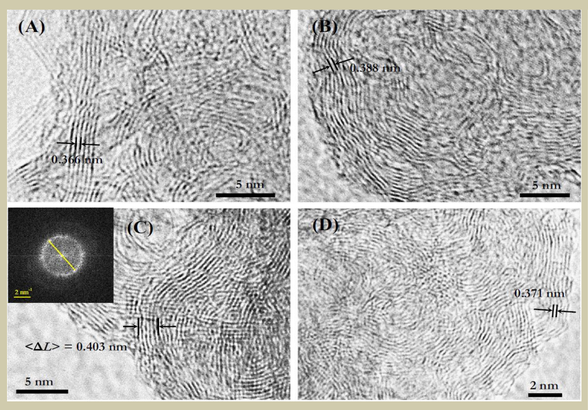
Graphitization of 20 μm SiC particles

Field Emission Scanning Electron Microscopy

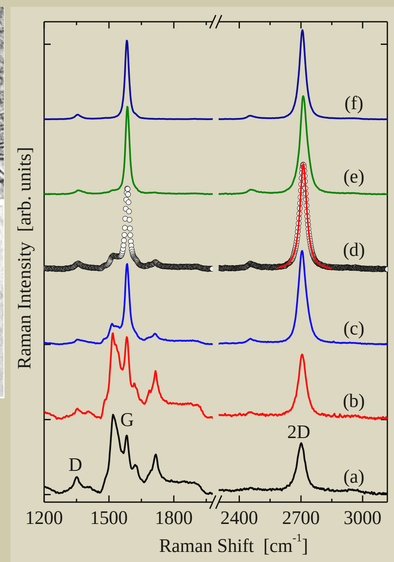


Typical FE-SEM images of laser-processed SiC particles (20 μm). From (a) to (h) images correspond to structures subjected to progressively higher dose.

HRTEM and Raman Spectroscopy studies



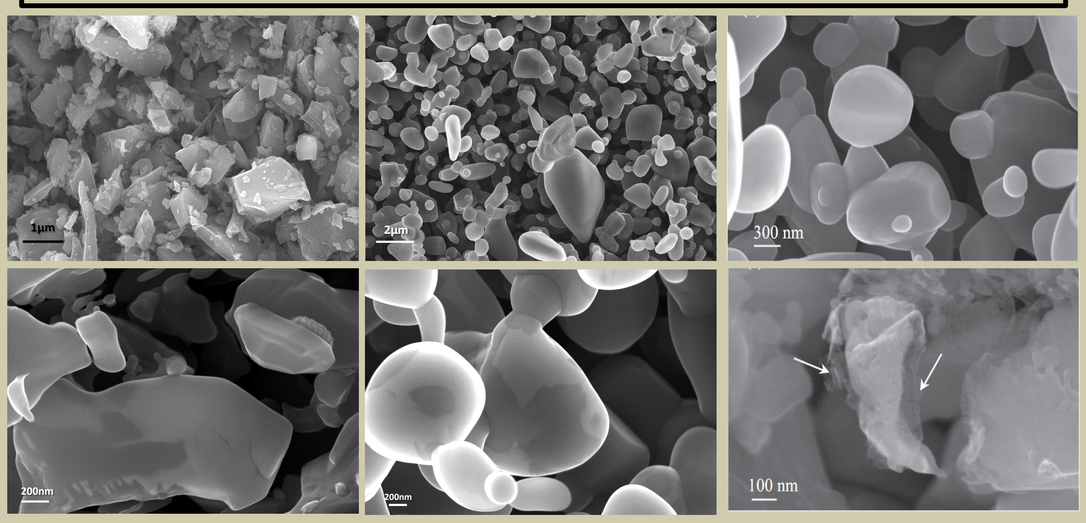
Typical HRTEM images of laser-processed SiC particles (20 μm). Characteristic interlayer spacing is shown, revealing an interlayer distance in all cases appreciably larger than that of graphite. The mean interlayer spacing for several layers is shown in (C).



Representative Stokes-side Raman spectra of laser processed SiC particles (20 μm). The 2D band of spectrum (d) has been fitted by a single Lorentzian line shown by the solid line passing through the data points. The Raman spectra, from (a) to (f), roughly correspond to specimen regions from where the FE-SEM images 2(b) to (g) were recorded.

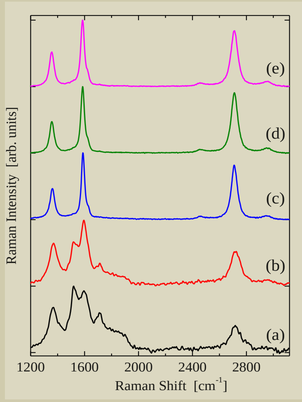
Graphitization of 2 μm SiC particles

Field Emission Scanning Electron Microscopy



Typical FE-SEM images of laser-processed SiC particles (2 μm)

Raman Spectroscopy study



- ✓ Representative Stokes-side Raman spectra of laser processed SiC particles (2 μm). Their intensities have been normalized to unity (for the more intense band) and their baselines have been off-set for clarity.
- ✓ In all cases, the single Lorentzian line-shape of the 2D band, reveals the growth of graphene-like films.

More details can be found in:
A. Antonelou, V. Dracopoulos and S. N. Yannopoulos, Carbon 85, 176–184 (2015).

Concluding Remarks

- The results presented here demonstrate that depending on the SiC particle size and irradiation details, graphitization can take place under various morphologies
- Laser-induced graphitization is evidently a versatile and adaptable technique for the preparation of carbide-derived carbons from inorganic precursors
- Scalability of laser-assisted graphitized SiC particles production to large scale appears realistic in view of the high rate of laser processing (short time decomposition)

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