Manufacturing Technology II
Class Assignment

Laser Machining of SiC in Microelectromechanical Systems

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Types of Lasers Used

The most commonly used types of laser in machining SiC in MEMS systems are:

- Nanosecond pulsed UV lasers such as excimers
- Frequency tripled and quadrupled Nd:YAG lasers

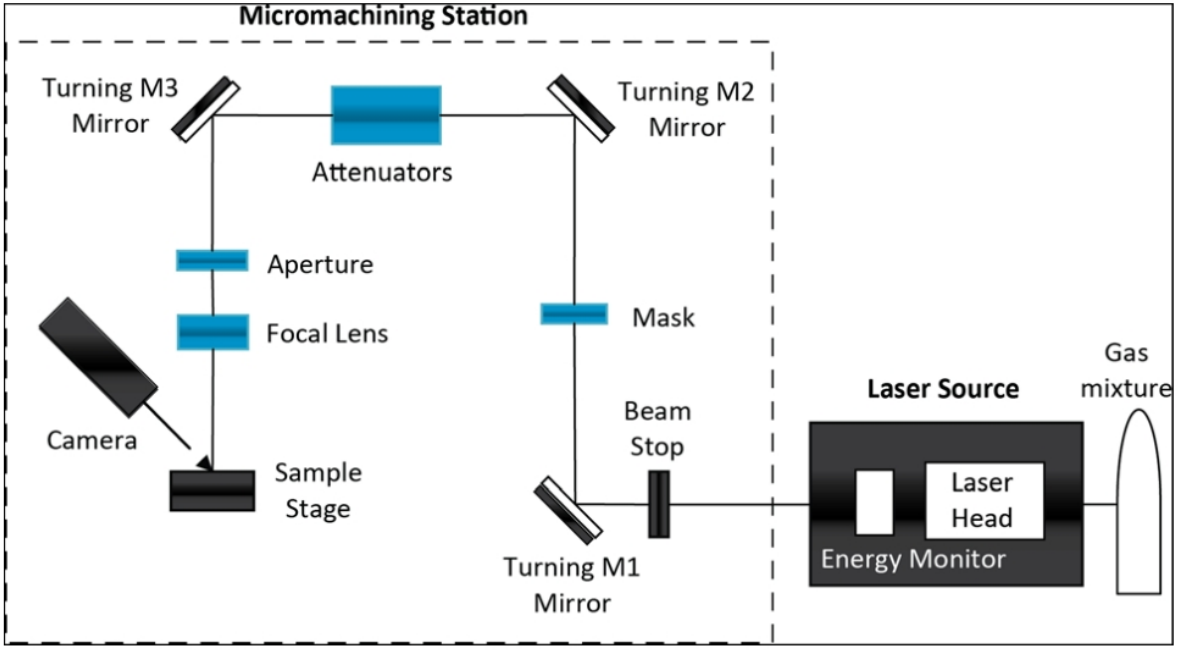

Fig. 1: Schematic drawing of excimer laser micromachining station (RapidX 250)

Why The Lasers Are Used

While virtually every laser technology applicable to microfabrication has been explored in micromachining SiC in MEMS systems, the laser technologies are chosen due to:

1. Their prevalence – they are common laser technologies.
2. High optical absorption of crystalline SiC at UV wavelengths.

Silicon carbide is practically transparent at visible wavelengths, but has an optical absorption on the order of 10^{-5} cm^{-1} in the UV region due to higher-than-band-gap photon energy.

IR pulses have also been explored for single-crystalline 4H-SiC where the ability to machine is a result of photons directly interacting with the lattice rather than through electrons.

Laser Parameters That Make Them Suitable – Excimer Laser

Excimer Laser in not continuous wave but a pulsed laser with a 20ns pulse duration.

The peak power is 7.54 x 10^15 W/m^2, much higher than the average power. It delivers significant amount of heat flux within the time period of a pulse width. This results is a rapid material removal rate.

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As the frequency does not affect surface quality significantly, higher frequencies can be used to make up for slow etching time due to low fluence.

Higher fluence leads to generation of more material debris around the ablation site, thus low fluence is used for laser ablation in order to obtain a better surface finish.

Laser Parameters That Make Them Suitable – Nd:YAG Laser

Nd: YAG laser has an important role due to:

1. Its high efficiency
2. Possibility to tune it in different wavelengths from infrared till ultraviolet
3. Change pulse duration from milliseconds down to picoseconds

For a pulse duration t_p=10 ns, the removal threshold of SiC is strongly dependent on the wavelength in the range 355 – 1064 nm.

For λ=355 nm, the removal threshold is 0.6 J/cm^2 for a pulse duration t_p = 10 ns. Similarly, the removal threshold of Si_3N_4, exhibits a dependence on the wavelength of the laser radiation under investigation, which is weaker and less pronounced than for SiC.

References

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