

# Renewable Forsterite Production by a Solar Furnace

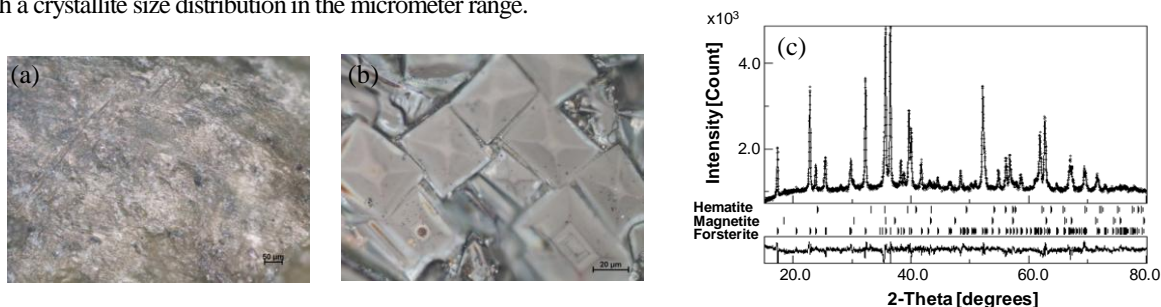
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Forsterite is a crystalline magnesium silicate with chemical formula  $Mg_2SiO_4$ , which has extremely low electrical conductivity that makes it an ideal substrate material for tunable laser. Forsterite single crystals doped with tetravalent chromium ions,  $Mg_2SiO_4:Cr^{4+}$ , are widely used as active media of solid-state lasers tunable in the range of 1.13–1.37  $\mu m$  [1] and mode-locked lasers generating ultrashort pulses [2]. Additional doping of  $Mg_2SiO_4:Cr$  crystals with lithium makes it possible to tune solid-state lasers in the spectral range of 1.03–1.18  $\mu m$  [3]. Different procedures have been used to prepare forsterite ceramics, such as solid-state reactions and sol-gel techniques. However, they are complex and costly. Forsterite can be formed by thermal decomposition of serpentine minerals,  $Mg_3Si_2O_5(OH)_4$ , which are widespread in the world. This method requires high temperature ( $\sim 900$  °C), and additives were added to reduce the decomposition temperature and thus the cost associated with high temperature processes [4]. Solar power is the ultimate renewable energy source. High temperature solar furnaces have been used for the production of many types of products. With a heliostat-parabolic mirror solar energy collection and concentration system, the sample in the focal zone can be heated from ambient temperature to very high temperature within seconds. To the best of our knowledge, we report here the first use of solar furnace for the production of forsterite from serpentine. Compared with other existing processes, this renewable, simple, fast and cost-effective method constitutes a very effective alternative to forsterite production.

A large plane mirror, composed of 16 flat segments, was mounted on a two-axis heliostat which redirects the incoming solar radiation towards a stationary parabolic mirror concentrator with 1.52 m diameter. The serpentine mineral was placed at the focal zone of the furnace and heated during three different times: 2, 4 and 8 s.

The surface morphology of the serpentine sample before and after thermal treatment was observed with the optical microscope (Fig. 1a,b). As shown in Fig. 1b, 2 s of thermal treatment with 1050 W incident power on the sample was enough to promote significant morphological changes on serpentine. The thermally treated mineral reveals a polycrystalline structure with a crystallite size distribution in the micrometer range.



**Fig. 1** Photograph of the serpentine sample (a) before and (b) after thermal treatment during 2 s. (c) MAUD refinement of the XRD pattern of the thermally treated mineral heated during 2 s.

The diffraction spectra accompanied by refinement results for the mineral heated during 2 s is shown in Fig. 1c. All the X-ray patterns for the samples heated during 2, 4 and 8 s reveal that forsterite with an orthorhombic structure (Pbnm) is the dominant phase. The quantitative phase analysis obtained by MAUD program revealed that the thermal decomposition of serpentine during 2 s in the solar furnace formed 97.3% of crystalline forsterite. Magnetite and hematite were also present in small amount, 2.2% and 0.5%, respectively, because the initial serpentine sample contained small quantities of magnetite. With increasing heating time (4, 8 s) other mineral phase, as enstatite, also appears in samples ( $\sim 3\%$ ). Therefore, we can roughly estimate that the temperature on the focal zone on serpentine reached around 800-900 °C in only 2 s, being the optimum time to produce forsterite in the solar furnace for an incident solar power on the sample of 1050 W. After 4-8s, the temperature at the sample was probably about 900-1000 °C, because enstatite crystallization occurs at temperatures above 900 °C.

In order to obtain pure forsterite a single demagnetization step could be applied initially to remove the magnetite fraction from the original sample. Therefore, pure crystalline forsterite from serpentine could be produced by the solar furnace.

## References

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