IN-SITU OBSERVATIONS OF MICROWAVE PROCESSING FOR FERROIC MATERIALS IN THE H-FIELD

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Roy and co-authors reported the crystals of the ferroic oxide heated very fast and rendered non-crystalline in a few second in H-field of the microwave. The results predict that the magnetic field play more important role than electric field to the ferroic materials.

NIFS offered an in-situ measurement system to Penn State-U for the investigation of the process while microwave was taking place. It was a kind of microscope with relatively long focal length of 60mm. The 18Mbites CCD assisted to zoom up the pictures for finer observations. The minimum resolution was 5μm.

A pellet of compacted mixed powder of $BaCO_3$ + 4 Fe_3O_4, holding in a quartz cylinder, was put on near the sidewall of waveguide cavity where the H-field was the maximum.

The in-situ observation reviled new world. It showed clearly the excitation of local heat spots in the test piece. Tiny bright cores, in a scale of 0.1 mm, appeared in a few second after the microwave switched on and heated up rapidly to exceed the melting temperature, while the other, including back ground, remained in the solid phase. The huge temperature differences are created within a few hundred microns and maintained for several seconds. The temperature gradient was estimated to exceed a few thousand-degree C in 1mm. The temperature measured by IR pyrometer stayed in 1000℃, as it indicated the average in the 2 mm circle including hotter cores and colder parts. It is the reason why the de-crystalline seemed to come at lower temperature as 1000 ℃.

The selective and an-isothermal heating can be the origin of so-called “microwave effect” such as lower sintering temperatures, enhancement in reaction and diffusion kinetics, etc. It is not clear, why such huge temperature gradient is excited in the microscopic level and exists stably for a moderate time scale of several seconds? The behavior of heat spots will be explained thermodynamically in terms of entropy, enthalpy and free energy. The real unknown, of course, is the absorption and relaxation mechanism(s) and what are the facts they must explain? Based on results in these experiments, it appears that magnetic decrystallization occurs in a wide range of materials and involves absorption from ambient to modestly high temperatures. The availability of unpaired electrons appears to be a necessary, although not sufficient, condition for the occurrence of magnetic decrystallization. More detailed experiment and theoretical studies will give the answer.

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