A MODEL OF MILLIMETER-WAVE HEATING OF SILICON POWDER COMPACTS

Yu.V. Bykov, S.V. Egorov, A.G. Eremeev, I.V. Plotnikov, K.I. Rybakov*, V.E. Semenov and A. Rachkovskiy[1]

Institute of Applied Physics, Russian Academy of Sciences
46 Ulyanov St., Nizhny Novgorod 603950 Russia

[1]Russian Federal Nuclear Center
37 Mira Prospekt
Sarov 607190 Russia

A considerable interest in recent years has been drawn to microwave heating of conductive powder materials. This type of microwave heating is sometimes difficult to understand due to lack of suitable models in the literature. This presentation suggests a model of a microwave process for heating silicon and discusses experimental validation of this model.

The model describes heating of silicon powder compacts in the applicator of the 24 GHz gyrotron system equipped with multi-channel temperature monitoring [1]. To calculate the electromagnetic power deposited in the compacts, the electrodynamic problem of plane electromagnetic wave incidence on a spherical body is solved [2]. The dielectric properties of the compact are expressed via the properties of its constituents via the effective medium approximation [3], which takes into account the density of the solid phase in the compact and also assumes that each individual spherical silicon powder particle in the compact may be surrounded by a concentric dielectric layer (silicon oxide or nitride). The existence and thickness of this layer are determined by comparing the model to experiment as explained below.

The actual power deposited in the compact is determined from temperature measurements in the center and on the surface of the compact, assuming for simplicity that the temperature dependence on the radius of compact is parabolic. The actual field strength in the electromagnetic wave incident on the sample was determined in calibration experiments with metal samples (titanium, aluminum, stainless steel) with well-characterized conductivity.

The results of calculations and their comparison with experiments will be discussed in the presentation. The presence of insulating shells on individual conductive particles prevents the connectivity percolation between the particles and increases significantly the electromagnetic power that can be absorbed by the compact.

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