NOBLE GASES FROM THE PLANETARY NEBULA STAGE OF STELLAR EVOLUTION IMPLANTED IN METEORITIC SiC GRAINS. A. B. Verchovsky, I. P. Wright and C. T. Pillinger, PSSRI, The Open University, Walton Hall, Milton Keynes MK7 6AA, UK (a.verchovsky@open.ac.uk).

Introduction: The isotopic compositions of noble gases found in SiC grains separated from meteorites clearly reveal a signature of s-process nucleosynthesis [1] which points to the AGB stars as a potential source of the grains [2]. It has been suggested [1] that the means by which noble gases are incorporated into SiC grains involves ion implantation. In the present study we have used a theoretical model of ion implantation which allows us to calculate the implantation energies of isotopically different components. Two main implantation events in the history of SiC grains have been established and identified with certain stages of AGB star evolution.

Model: The developed model [3] considers ion implantation into spherical grains in space and predicts that concentration of implanted species increases with grain size at low ratios of grain diameter (D) to implantation range (S). A unique solution for the implantation range (and, consequently, energy) from the observed dependence of concentration on grain size can be obtained only in the case of D/S<6. Variations of noble gas concentrations in Murchison SiC grain-size fractions [1] provide a good fit to the criteria. The model also predicts systematic isotope variations with grain size assuming two isotopically different components were implanted with different energies. This also corresponds to the observations for the Murchison SiC grains [1] containing s-process noble gases (G component with variable Kr isotopic composition) as well as isotopically normal (N) component.

Results: Applying the model calculations to each component we found that their implantation energies are significantly different. S-process Xe and Kr with low ^{86}Kr/^{82}Kr ratios have relatively low implantation energy (<1 keV/nucleon) whilst for He, Ne, Ar and Kr with high ^{86}Kr/^{82}Kr ratios the energies are much higher (~40 keV/nucleon). Such a big difference in the implantation energies of the noble gas components appears to imply significantly different physical processes. The low energy component seems to have been implanted during expansion of AGB stars [4] and occurred at relatively low temperature (~3000 K) and speed (10-30 km/s). The high energy component requires relative speed of few thousand km/s that can only be achieved during the post-AGB stage of evolution [5] when the star becomes much hotter (T~10^6 K) and the stellar envelope is separated. This is the planetary nebula formation stage.

Elemental compositions of the components are also quite different, and these can be explained by fractionation during ionization at different temperatures. Such a scenario of implantation events for SiC grains can explain why grains containing He and Ne account for only ~5% of the whole population [6] as well as very low ^{20}Ne/^{22}Ne ratios observed in the grains [1].

Ion implantation with relatively low energy seems to be a dominating incorporation mechanism for s-process Ba [7] and Sr [8] in the Murchison SiC grains.

References:

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