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Atom movement in solids studied using PAC spectroscopy

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Perturbed angular correlation of gamma rays (PAC) is a nuclear hyperfine interaction spectroscopy that has been used to study solids for 50 years. In particular, local environments of radioactive probe atoms can be flagged by interactions between the probe's nuclear quadrupole moment and electric field gradients (EFGs) arising from nearby charges. Recently, it was shown that one can use PAC to study diffusion of probes through stochastic fluctuations of the EFG that lead to nuclear relaxation [Phys. Rev. Lett. 92, 225901 (2004)]. Jump-frequencies can be measured with much less effort than tracer diffusivities and have comparable precision. In this talk I will outline features of the method and survey recent investigations of highly-ordered intermetallic compounds made in our laboratory using the ^{111}In/Cd probe. These include cubic phases having the Cu_3Au structure, in which the EFG fluctuates in orientation but not in magnitude, and of tetragonal phases having the Al_4Ba structure, in which the EFG fluctuates in magnitude but not in orientation. Furthermore, it will be shown that PAC can be used to determine whether vacancy diffusion in a binary phase A_nB_m predominantly involves A-vacancies or B-vacancies [Phys. Rev. Lett., in press]. In a recent study of a large series of In_3R phases (R= rare-earth), it was found that In-vacancies control diffusion in heavy lanthanide indides and R-vacancies in light lanthanide indides. The change in diffusion mechanism was found to be correlated with lattice parameter, which decreases monotonically through the series. However, the change is, in itself, a surprise given the very similar chemistry of rare-earth elements. *This work was supported in part by the NSF under grant DMR 05-04843 (Metals Program). Group web site: http://defects.physics.wsu.edu/.*