Atom Probe Tomography (APT) is the only analytical microscope able to map out the distribution of chemical species in materials at the atomic-scale in the three dimensions. It has shown to be a quantitative instrument for the measurement of phase composition in solids including metals, oxides, and semiconductors. The volume that can be reconstructed is close to 50x50x100 \text{nm}^3 \text{ (figure 1).} The composition in a small selected volume (1 \text{nm}^3) within this volume can be measured. The spatial resolution of the instrument is 0.1 nm in depth and a fraction of a nm at the specimen surface. The first French prototype (the tomographic atom probe-TAP) was designed and set up in the lab in the early nineties and subsequently marketed by CAMECA [1]. With the development of laser-enhanced instruments, the investigation of non-conducting materials (oxides, semiconductors) was made possible [2]. Together with the use of FIB techniques for the preparation of specimens, this innovation has opened a considerable development of APT in nanosciences (e.g. spintronic) including microelectronics [3].

Because of its ultimate spatial resolution and quantitativity in composition measurements, APT is a well suitable technique to investigate the early nucleation of a new phase in solids as well as the segregation of impurities to Cristal defects (grain boundaries, dislocations (figure 1), stacking faults...)[4]. APT has also been extensively employed to study precipitation kinetics (figure 2). One of the force of APT is that 3D images can be directly confronted to Kinetic Monte-carlo simulations (rigid lattice) [5]. The composition and structure of nuclei during the early stages of solid state phase separation in binary systems is a challenging problem both from a theoretical and an experimental point of view and is of utmost importance for applications. APT investigations showed that nuclei have sometimes a solute concentration smaller than the equilibrium phase [6]. In this presentation, the role of APT in material science will be illustrated through a few selected examples related to segregation to crystal defects and to the early stages of precipitation.

Fig. 1: 3D reconstruction of a Cottrell atmosphere in boron-doped FeAl intermetallics (iron is not represented for the sake of clarity). APT image reveals the segregation of boron atoms to the dislocation line. Boron concentration (2at.%) was found to be 400 times the nominal composition (400 at.ppm). Note the presence of an Al-depleted zone.

Fig. 2: 3D map (107 atoms - 40x40x150 nm$^3$) of a model nickel base superalloy containing small Al-enriched precipitates (7 nm). Small Al-enriched precipitates (7 nm in diameter, 18at.%) embedded in a Cr-enriched parent phase are evidenced.