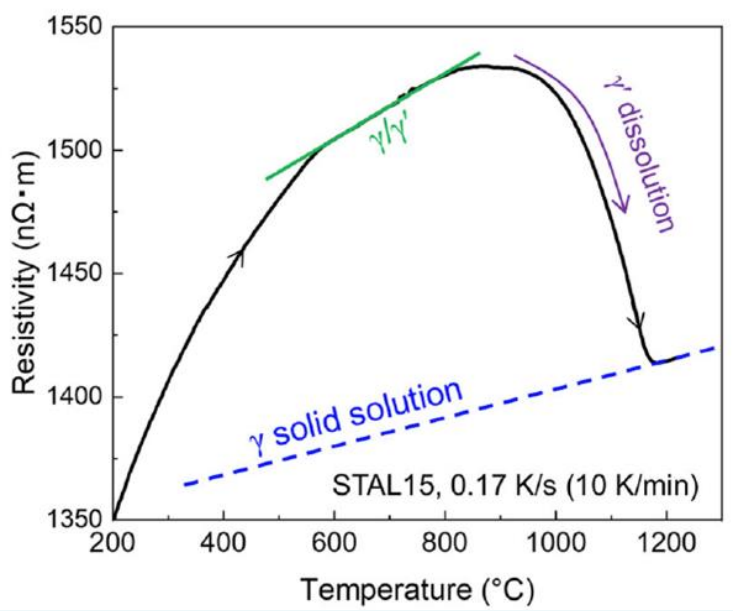
Sujet de mastère spécialisé MapMod rentrée 2023

TITLE	Tracking of precipitation kinetics in nickel-base superalloys using electrical resistivity measurements
Project acronym	PResiste
Image (recommended)	
Caption of the image	Resistivity measurement during the heating of a STAL15 nickel-base super-alloy (form [2])
Thesis work description	Airplane jet engine turbine blades undergo extreme thermal and mechanical conditions during use. In a jet engine, the turbine blades that meet the most severe conditions are made in nickel-base super alloys with a single crystal structure. Mechanical properties of these parts highly depend on the distribution of gamma' precipitates in the gamma matrix. This is the case in service, but also during the different steps of the manufacturing route of the blades: directed solidification and heat treatment. To optimize these manufacturing steps, it is important to get a good knowledge of the mechanical behavior of the material. Therefore, the knowledge of the precipitation kinetics is essential, as well as the link between the volume fraction of precipitates and the parameters of the constitutive law. A fast and reliable measurement of the volume fraction of the gamma' phase is therefore of interest when characterizing the mechanical behavior of the material by various mechanical tests. The electrical resistivity method seems promising to characterize the volume fraction of precipitates in an indirect and non-destructive way [1, 2].
Objectives	The objective of this master project is therefore to establish the link between the electric resistivity measure and the volume fraction of gamma' in single crystal samples. Preliminarily, a bibliographic study will review all the metallurgical and physical contributions to electrical resistivity: solute concentration in the matrix gamma phase, intrinsic resistivity of the gamma' precipitates, gamma/gamma' interface, lattice defects (pre-strain), temperature, etc. Then, an experimental plan will be defined to measure the evolution of electrical resistivity of samples submitted to various thermal cycles. These tests will be done on the Dedimet machine in CEMEF, where resistive

	heating by Joule effect allows flexible thermal cycling. These local measurements (close to the center of the specimens) will be compared to post-mortem measurements of gamma' volume fractions using SEM and XRD. Some selected samples will be analyzed in situ during thermal cycle with a special XRD equipment. Thermo-Calc based calculations will be used to help the definition of the experimental plan and the establishment of the law linking the resistivity value to the volume fraction of precipitates. Analysis of several processing histories, so that different initial microstructures, could be also of great interest.
References	[1] B. Roebuck, D. Cox and R. Reed, The temperature dependence of □' volume fraction in a Ni-based single crystal superalloy from resistivity measurements, Scripta mater. 44 (2001) 917-921 [2] S. Utada, R. Sasaki, R. C. Reed, and Y. T. Tang, In-Situ Monitoring of Phase Transition and Microstructure Evolution in Ni-Based Superalloys by Electrical Resistivity: Direct Comparison With Differential Scanning Calorimetry and Application to Case Studies, Metallurgical and materials transactions A, 54A (2023) 1549-1567
Type of project / Project partners	Industrial contract with company SAFRAN Tech
Thematic / Industrial Field	Aeronautics
Key-words	Solidification
Skills and abilities requested	Engineer or master
Gross annual salary	
Location	CEMEF, Sophia Antipolis, France SAFRAN Tech, Gennevilliers, France
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