An image analysis approach for the structural characterization of pyrocarbons

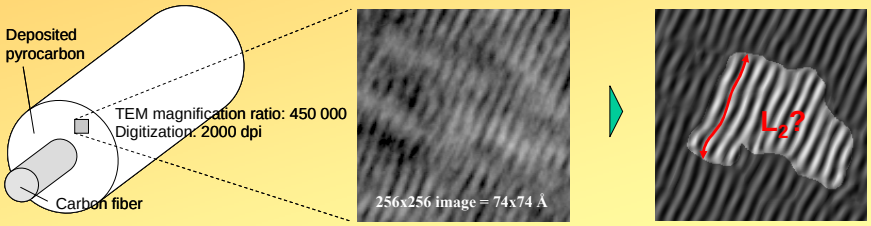
JP. Da Costa[1,2], C. Germain[1,2], P. Baylou[1], M. Cataldi[3]

[1] Equipe Signal et Image - LAPS - UMR 5131 CNRS - 33402 Talence cedex France
[2] ENITA de Bordeaux – BP 201 - 33175 Gradignan cedex France
[3] Snecma Propulsion Solide, Groupe Snecma, Les Cinq Chemins 33185 Le Haillan.

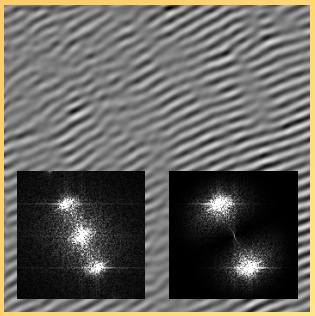
E-mail contact: jp.dacosta@tsi.u-bordeaux1.fr

Abstract

We focus on the nanometric structure of pyrocarbons obtained by Chemical Vapor Infiltration and observed by High Resolution Transmission Electron Microscopy (HRTEM) imaging. More particularly, we present an automated approach to the quantitative description of fringe lengths and we propose a simple stochastic model for fringe description which corroborates the obtained length statistical distributions.

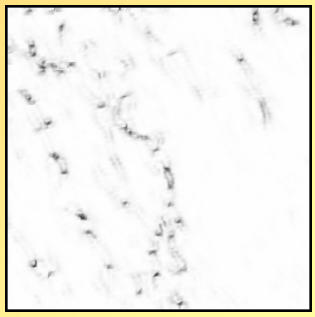


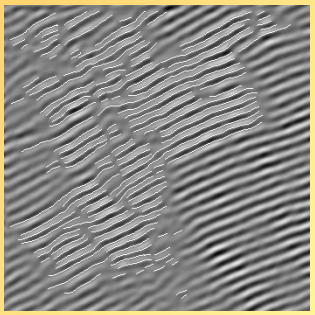
The Fringe Extraction Algorithm



Directional filtering in the frequency domain

Detection of fringe endings



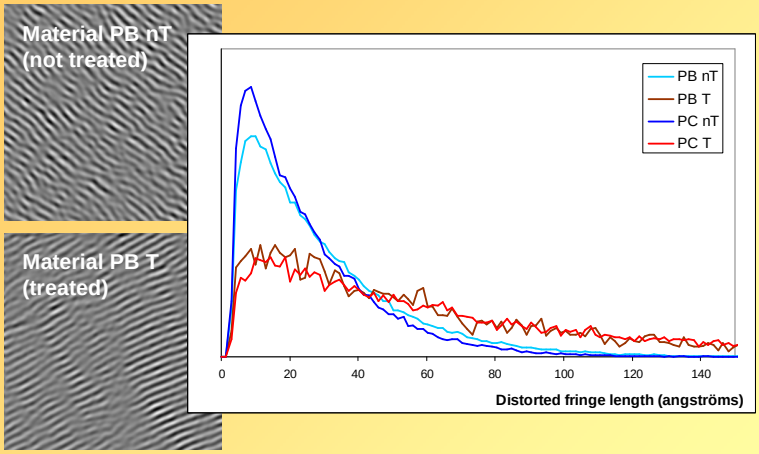


Fringe extraction by level curve tracking

Da Costa, Germain, Baylou, "Level curve algorithm for textural feature extraction", Proc. of ICPR 2000, pp. 921-924.
Da Costa, Germain, Baylou, "A curvilinear approach for textural feature extraction", Proc. of QCAV 2001.

Fringe Length Statistics

Fringe length statistics have been computed on 4 image sets: 2 fabrication processes, 2 thermal treatments.



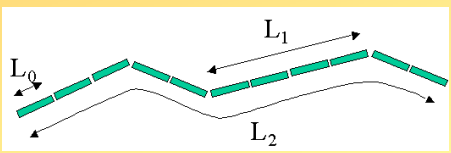
Results

- distributions characterized by one mode and an exponential decrease,
- the position of the mode and the speed of decrease depend on the material and on the thermal treatment,
- the effect of thermal treatment is clearly shown,
- differences between 2 processes vanish with thermal treatment.

Towards a stochastic model for structure description

A simple model:

- fringes described individually;
- a distorted fringe (L_2) is an arrangement of straight segments (L_1),
- a straight segment (L_1) is made of aligned elementary segments (L_0),
- cohesion between 2 elementary segments: probability p_1,
- cohesion between 2 straight segments: probability p_2,
- L_0 follows a normal distribution $\mathcal{N}(l_0,\sigma_0^2)$.



$$P(L_2 = l) = (1-p).\sum_{k=1}^{\infty} \frac{p^{k-1}}{\sigma\sqrt{2k\pi}}.e^{\frac{-(l-kl_0)^2}{k\sigma^2}}$$

with $(1-p) = (1-p_1)\cdot(1-p_2)$.