InPact — the indium phosphide specialists

Didier Marsan, InPact

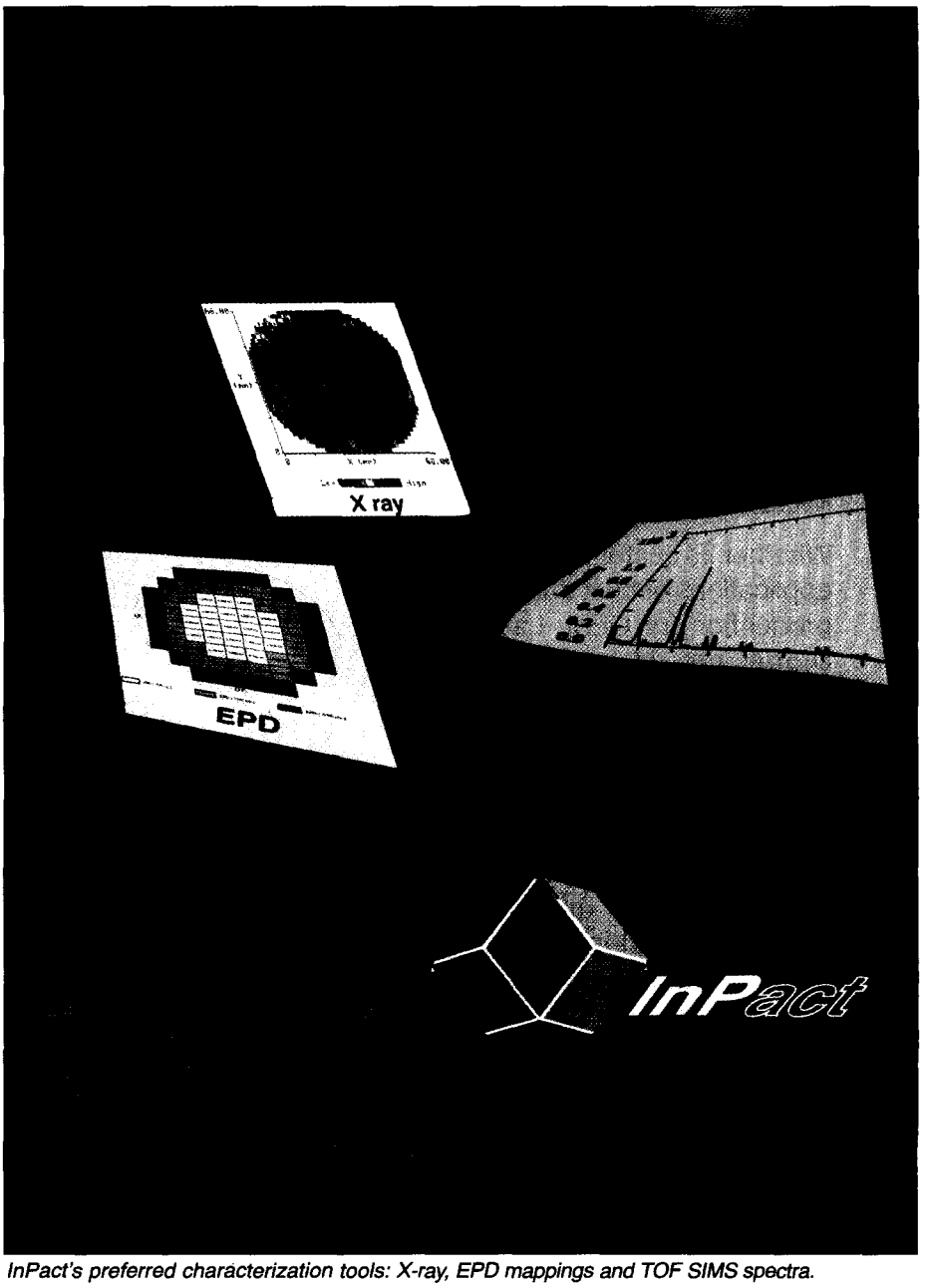
Since the management buy-out in 1995, InPact has changed dramatically and for the better. Sales have more than doubled, and the staff has grown from 11 to 25. Today, InPact claims to be the leading source of InP wafers outside Japan. We owe this growing success to the customers world-wide — who have been steadily putting more trust into our products; to our technical partners; and to our staff dedicated to providing high quality and first class service to all of our customers

In July 1995, Guy Jacob, Didier Marsan and Daniel Turover took over the company, formerly known as Métaux Speciaux and Crismatec-InPACT, with the objective to be the leading Western producer of epi-ready InP substrates.

The company was formed in 1988 by aluminium giant Péchiney to grow InP material using the liquid encapsulated Czochralski (LEC) method, under licence from France Télécom/CNET. About US$10 million were invested by Péchiney to build a plant containing state-of-the-art growth, polishing and characterisation equipment.

We believe that our growing success stems from a combination of four assets:

- first class service: a flexible organisation to supply our customers quickly and on time;
- a close and open technical communication with our customers;
- competitive pricing thanks to the growth of long boules (yielding up to 130 premium and mechanical grade wafers), and a lean organisation with limited overhead;
- a technical edge on specific issues like surface preparation and quality consistency from boule to boule.



InPact's preferred characterization tools: X-ray, EPD mappings and TOF SIMS spectra.

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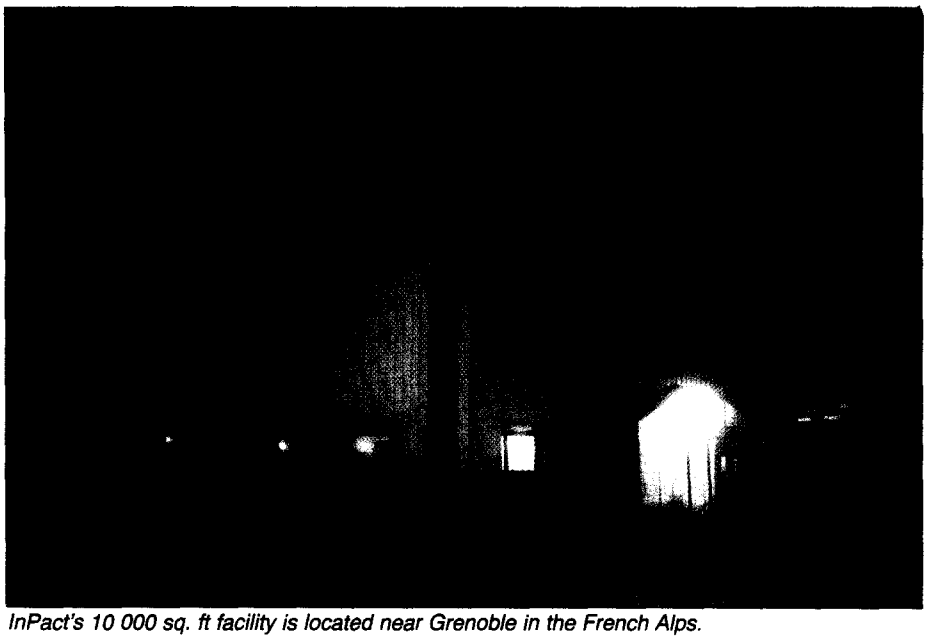
R&D programme and strategy

Listening carefully to the concerns and requirements of InP users around the world, we identified the areas in which to focus our R&D efforts. Given the absence of State subsidies in France for indium phosphide, we decided to set up a network of technical partnerships and joint research programs with some of the best specialists at each stage of the manufacturing process. This unusual strategy was designed to leverage the available resources in terms of know how, experience and equipment. It took about a year to identify the right partners and get down to work.

The technical challenges around such a difficult material as indium phosphide generated a lot of interest and as a result, we have been happy to develop several valuable relationships, especially with the furnace specialists at CEREM (part of the French Atomic Energy Agency-CEA); the growth modelling experts of Louvain la Neuve; and the epitaxy experts of KFA Jülich, LETI and CNET. Indeed, this strategy combining internal and external R&D effort has brought major technical breakthroughs in particular in the areas of bulk quality and surface preparation.



InPact's 10 000 sq. ft facility is located near Grenoble in the French Alps.

Bulk: cost-effective and reproducible stress-free material

We believe in the LEC growth method. It is a mature technology although it requires fine tuning, similar to silicon and GaAs growth in the past.

In house, we have been improving the growth conditions to reduce stress and suppress lineage of dislocations with a thermal baffle technology. Stress-free material with a FWHM of 13 arc sec over the whole surface, whatever the dopant is now our routine production. A dramatic improvement compared to 18–20 arc sec a couple of years ago.

In addition, a joint programme with CEA and Université de Louvain La Neuve is making good progress on modelling the thermal growth cond-itions. The objective is to better understand the origin of strain and to find ways to reduce dislocations further.

For bulk evaluation our preferred characterisation tools are:

- EPD mapping (69 points): more than the dislocation level itself, the distribution of dislocations over the entire surface provides accurate information on the stress in the crystal.
- X-ray diffraction mapping (2000 points): this scanning gives the true picture of the residual stress in the crystal, whether the material has some lineage of dislocations inducing strain and breakage during the technology steps or not. This method is useful as it scrutinizes the lattice distortion (the lattice mismatch related to sub-grains) and the misorientation (when some defects especially lineage of dislocations generate a tilt).

Surface: haze-free material with a new epiready process

The major goal is to achieve a wafer preparation which allows good and reproducible epitaxial layers. That means good surface morphology, a combination of high photoluminescence (PL) intensity/good PL homogeneity and as low a defect density as possible.

To achieve this, all wafer processing steps are critical: cutting, polishing and surface preparation processes. Still, our focus at InPact has been on the cleaning process. Several new epiready recipes were investigated and evaluated by MOVPE and MBE epitaxies. KFA

Facts about InPact

- InP poly and single crystal manufacturer, covering all dopants in 2-in and 3-in (Fe, S, Sn, Zn, undoped)
- Staff of 25 including: 8 PhDs or engineers and 5 dedicated to R&D
- 10 000 sq. ft plant located in the French Alps, near the high tech and research centre of Grenoble
- 120 clients in 20 countries

Jülich and CNET have here a major role.

The major achievement of these collaborations — something of a breakthrough — is the development of a new epiready process which gives haze-free material and a lower silicon contamination too. The conduction layer at the interface (i.e. the number of carriers) is down to $10^{11}/cm^2$ which fits requirements for microelectronics (as described in our paper, in the IPRM 97 conference proceedings, page 420).

Two powerful instruments can be used to validate the surface preparation quality and check the quality consistency:

- Particulates counting. Actually not only the particulates are scanned but also the haze, i.e., the package of residual particulates which are not detectable and can hinder the epitaxy especially for regrowth.

- TOF SIMS. This innovative technique to scan the surface can be briefly described as follows: a primary low grazing ion beam hits a tenth of a monolayer at the surface, the ions induce collisions of atoms and molecules then emissions of secondary ions are mass analysed by a spectrometer. Two analyses are carried out: a quantitative one with the content of each element and a qualitative one with an accurate detection discriminating each element per mass. TOF SIMS has a higher sensitivity compared to XPS or Auger, for instance. One atom of contamination can be detected out of 10 000 atoms. In addition to our tracking systems for water, air and chemical flows, TOF SIMS measurements help InPact in adjusting the surface preparation steps and in better pre-vention of surface contamination.

Contribution of InPact to industry

From this two year comprehensive research program we have drawn a few conclusions:

- The InP niche industry is booming and the InP technology is at its infancy compared to Si or GaAs. Continuous research is necessary to help improving the product and providing the market with even better material.

- No one can have the monopoly on the best quality permanently, as the issues are numerous: stress and dislocation density for 3-in diameter material — for the bulk quality; wafer flatness, flat angle tolerance, surface contamination, epiready preparation consistency — for the surface quality.

- Throughout the world, customers have different needs and requirements. We try as much as possible to customize our products and services accordingly.

- A dual sourcing for customers — a Japanese and Western supplier — may be the way to get state-of-the-art material over the long term. Indeed competition between Japanese and Western producers helps advance cost, service and technical developments.

InP dedicated

InPact is dedicated to InP substrate manufacturing (from polycrystal to pulling and surface preparation for any dopant and diameter).

We have been committing large resources since 1995 to both in-house and through collaborations to achieve a leading position for bulk quality consistency (stress-free LEC material boule to boule) and a technical edge on surface preparation (haze-free surface with low contamination). Even though there are still some challenges.

InPact, as InP specialists, is on its way to becoming the leading Western supplier.

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