New Applications for Ceramic Injection Moulding

A unique producer of translucent ceramic components for Philips' high intensity discharge lamps, Philips Ceramics Uden is now helping customers in other industries benefit from its innovative ceramic injection molding (CIM) techniques. The company has invested heavily in developing CIM technology and in mechanisation over the last 10 years in order to deliver heavy duty high precision products at competitive prices. Philips Ceramics Uden is now well placed to develop pioneering products to benefit both industrial and consumer markets.

The company *Philips*, the world's leading manufacturer of high intensity discharge (HID) lamps, founded the Uden (The Netherlands) plant in 1953 to produce elements for its lamps. Originally, Philips assembled the high tech burners, made of high density polycrystalline alumina (PCA), from five pieces, all made by extrusion. By introducing CIM technology, however, *Philips Ceramics Uden* was able to develop a new 2-piece design for the HID lamp burners and significantly improve the quality of light produced (Fig. 1). High volume production and comprehensive process automation allow the company to manufacture its very high precision ceramic products at competitive prices.

The technical development team at Philips Ceramics Uden has vast experience in ceramic materials and related manufacturing technologies, and continues to innovate, and to optimise the following:

- **Process development:** all aspects of the manufacturing process, such as compounding technology to produce a homogeneous feedstock that is free of contamination, injection molding technology including special-wear resistant coatings, de-binding, assembly techniques and sintering

Keywords
translucent ceramics, discharge lamps, ceramic injection molding

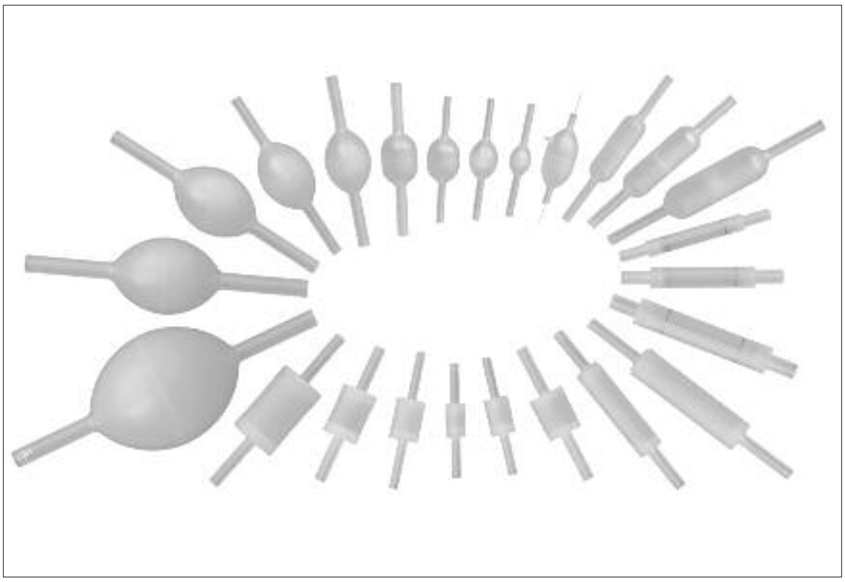

Fig. 1
PCA burners made by injection molding and extrusion

- **Product development:** delivering a solution with the best performance at the lowest cost. The team specify the raw materials, select dopes at the right concentration, and refine the details of the design
- **Equipment engineering:** the architecture of the entire plant, process automation and the industrialisation of CIM technology.

In particular, the development team in Uden is committed to further improving the grades of raw materials, and optimising and further automating the CIM process.

Injection-moulding process

To avoid contamination of raw materials, the entire plant at Philips Ceramics Uden is spotlessly clean, doors are hermetically sealed, and the kneaders for feedstock preparation have alumina linings. In addition, by carefully controlling the molding and sintering stages, Philips ensures a consistently high quality end product.

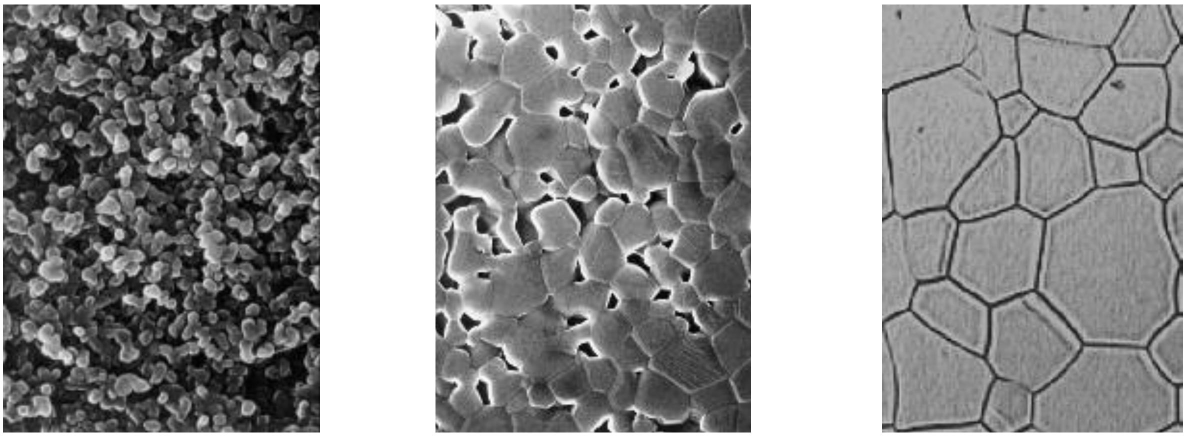

Fig. 2
PCA microstructure at: 1200 °C (left), 1600 °C (centre), and 1850 °C (right)

The stages in the CIM process at Philips Ceramics Uden can be summarised as follows:
Feedstock compounding: the in-house knowledge and equipment for feedstock preparation brings a unique added value by providing special receipts/mixtures for advanced molding projects. This makes Philips Ceramics Uden independent of standard materials and receipts.
Injection molding: the cavities of each hot runner mold are filled with feedstock at a precisely controlled temperature, to ensure uniform coverage. The molds are then cooled and opened, and the parts automatically inspected by an optical camera.
De-binding: for several hours, the trays move through a space-saving transportation system in the de-binding area. Fresh water at approximately 50 °C is continuously supplied, before the parts are oven dried.

Tab. 1
Some properties of PCA

Property (Al_2O_3 > 99,9 %)	***Value***
Thermal range Temperature [K]	0–2000
Thermal properties Thermal conductivity [W/m·K] at 25 °C CTE linear [µm/m·K] at 25 °C	35–40 5,50
Electrical properties Dielectric strength [kV/mm]	>55
Gas tight properties Density [g/cm^3] Porosity	3,98 no open porosity
Chemical inertness Hydrolitic resistance	better than type 1
Stiffness Elasticity modus [GPa]	380
Hardness Mohs scale	9
Optical property TLT (total light transmittance) [%]	>98

Assembly: the two halves are assembled using a precise, fully automated process to create a gas-tight, barely visible seam. This seam is fully “monolythic”: leaving the intrinsic material properties of the surrounding components intact.
Sintering: the parts are heated in the pre-sintering furnace at a maximum of 1400 °C to gain sufficient strength to be handled further. Then, in the sintering furnace at 1850 °C in hydrogen, the PCA achieves a density higher than 3,98 g/cm^3 and acquires the desired translucence.
Fig. 2 shows the structure of the material at different stages of the sintering process.
Inspection: The finished parts undergo a final fully automated inspection with optical cameras.

Pioneering solutions for other industries
Now Philips’ development team is exploiting the design freedom of CIM technology to develop technical solutions for other industries.
Pieter Schoone, Plant Manager of *Philips Lighting*, says: “We have a lean management structure in order to be able to realise technological innovation quickly and efficiently. Our target is to provide sustainable supplies and continuously improved customer service, and we are striving to always be a competent, reliable and flexible partner for our customers.”

Properties of ceramics
Technical ceramic products offer a unique combination of characteristics: they are chemically inert, non-porous, resistant to

Fig. 3
Injection moulding machine

pressure and temperature, scratch-proof and non-corrosive.

The properties of translucent PCA (Tab. 1), for example, mean that it can replace sapphire at less than one-fifth of the cost.

Philips' CIM technology can be applied both to translucent PCA and also to other types of ceramics (zirconia, cermets), chosen to achieve the optimal mechanical performance for the specific application.

New applications for CIM technology

Suitable applications for Philips' CIM technology include:

- crucibles for thermal analysis in laboratories
- parts for the automotive, space and medical industries
- temperature-sensor housings
- advanced optical applications
- consumables for chemical and analytical equipment
- feed-through solutions and vacuum-sealing applications
- vials for certain medicines and chemicals
- design and high wear parts for consumer products.

With its CIM technology, Philips delivers end products with greater precision and reliability than those produced using traditional methods such as extrusion. Customers who need high-volume production can also achieve time and cost benefits with Philips' automated methods.

The fascinating 60-year evolution of Philips Ceramics Uden is therefore set to continue as the company helps both industrial and consumer markets develop new applications of its ground-breaking technology.

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