Integrated Biophotonic Circuits

Innovative new advanced photonic integration techniques and the use of these to form Integrated Biophotonic Circuits (IBCs) is a new area being developed by the CIP Ltd in the UK. The Centre which was formerly part of British Telecom's Photonics Research Group and more recently the Corning Research Centre is applying it's broad and deep knowledge of photonics to new applications in the biotechnology market. Photonics has been used in the biotechnology industry for many years now, however CIP is now applying its innovative advanced photonic integration techniques to develop application solutions hitherto not possible with discrete devices.

With ever increasing calls on size, cost and functionality for biophotonic chips the use of advanced integration techniques will lead to innovative "lab-on-a-chip" circuits that are capable of doing many tests at the same time thus reducing process time and speeding up the decision making process.

The use of buried waveguides, figure 1, to route light has been utilised in the communications industry for many years now. It is the optical equivalent of the electronic printed circuit board. However the application of this in biophotonics has been limited. Buried optical waveguides in various materials including glass, silica-on-silicon and lithium niobate have been available since the 1980s. Each of these materials offers differing properties for the guiding of light. Although they do not offer the extremely low losses of silica optical fibre, the requirement for transmission over many kilometres with extremely low loss is not required in the applications here.

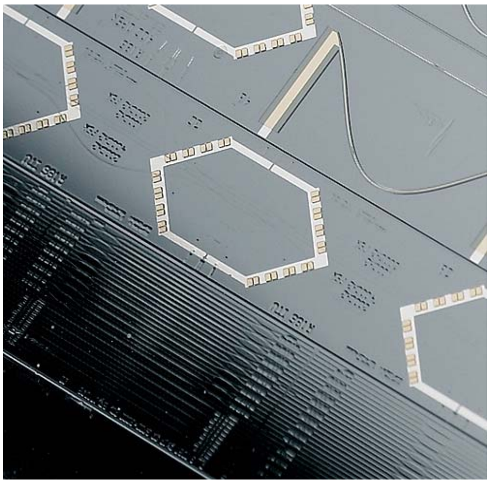

Figure 1: Silica-on-silicon optical waveguide device

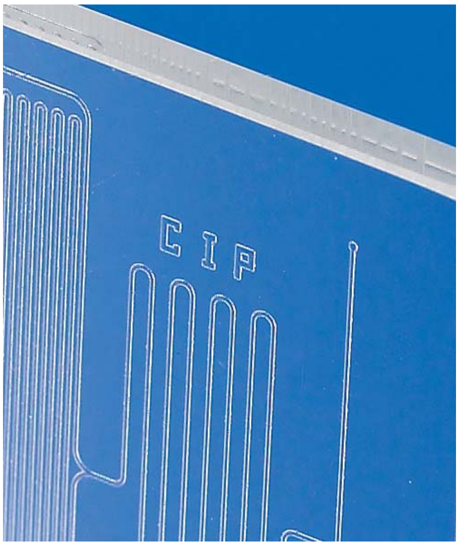

Figure 2: Glass microfluidic plate

Thus light can be routed around a "biophotonic chip" with low loss. The use of this method also allows the flexibility to route the light on-chip to different evaluation cells allowing parallel processing of information.

Microfluidic technology is the fluidic equivalent of the optical waveguide but carrying fluid rather than light. Fluid is carried in etched micro channels and can be reacted in very small quantities, very quickly and under pressure. A variety of materials can be used for these microfluidic plates depending on the application and the surface reactivity requirements for the reaction chamber. CIP has developed glass technology, figure 2, to mimic the use of glass test tubes with which the biotechnology industry is obviously familiar. An alternative to glass for very complex microfluidic channels is SU-8 resist technology. This can be used to define channels onto glass or silicon substrates. The SU-8 can either be utilised to define the channels, figure 3, or to make a positive stamp, figure 4. This stamp is then used to manufacture Microfluidic channels in less expensive substrate materials such as PDMS where the surface reactivity of the polymer channels does not present a problem.

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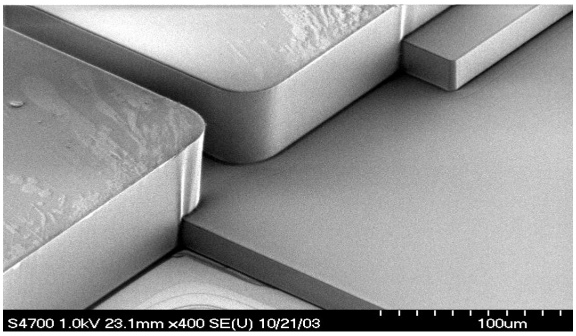

Figure 3: Microstructure formed in SU-8

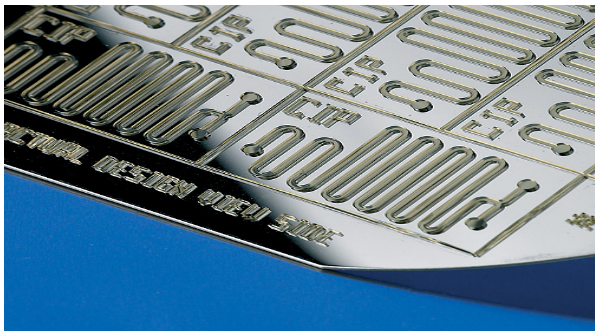

Figure 4: SU-8 positive mould

CIP has now combined buried waveguide and Microfluidic technology with thin film filter technology to produce Integrated Biophotonic Circuits (IBCs). These circuits will have a wide variety of applications in the drug discovery or biotechnology industries. Optical waveguides in a tantala layer deposited on top of a glass substrate allow for the routing of light around and under the Microfluidic channels formed on top of this waveguiding layer. Light may be coupled evanescently into fluids within the microchannels

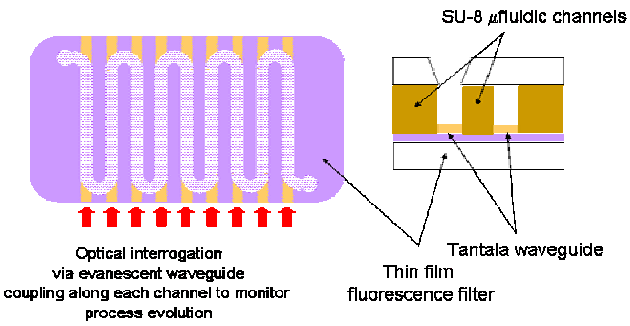

Figure 5: Tantala waveguide IBC

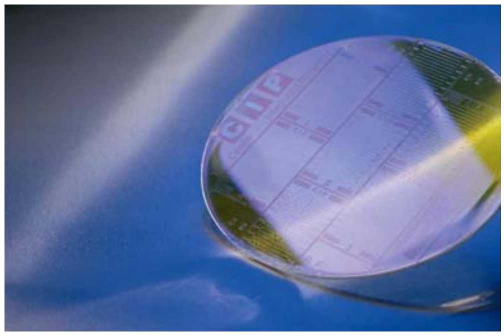

Figure 6: IBC wafer

and fluorescence or absorption detected and measured by means of either on-wafer photodiodes or through the substrate material and integrated fluorescence filters. A huge variety of designs are possible using this technique and arrays of LEDs or lasers may be used at the side of the IBC in order to launch light into the waveguides. Due to the wafer scale processing and normal semiconductor techniques used for the manufacture of the plates large scale production is possible with the resultant low costs in volume.

IBCs use a variety of techniques from both the semiconductor and photonics industries and apply these techniques in innovative new ways to allow increases in efficiency and cost in biotechnology applications. The techniques involved open up a whole new dimension in biotechnology product design. For more details contact CIP at info@ciphotonics.com.

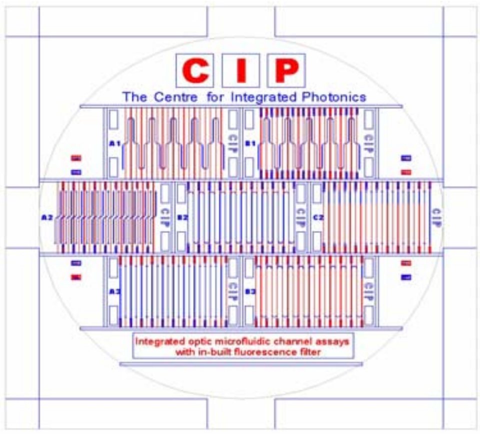

Figure 7: IBC wafer scale integration