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The Application of Acoustics for Sample Manipulation and Delivery at X-ray Light Sources

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Diamond Light Source is actively exploring acoustics for sample manipulation and delivery, primarily for synchrotron beamlines, but also at X-FELs. Sound is being exploited in two key ways: the first is to use acoustic energy to eject and deliver picolitre drops containing protein crystals in the range of 5-50 microns at a repetition rate up to 50KHz on demand; the second is the use of discrete transducers to create 'acoustic traps', areas of low pressure surrounded by high pressure. These traps are used to levitate and manipulate samples in both liquid suspension and solid form and present them to the beam. This combination of acoustics also offers the exciting possibility to do mixing experiments, e.g. adding reagents to crystalline sample prior to beam exposure to perform time-resolved diffraction experiments. Light activated experiments can also be carried out as well as reactions requiring heating, creating a 'virtual test-tube'where a reaction can take place in free space, free of contamination and with minimal attenuation for data collection. The acoustic ejection system supplied by Polypico is an effective solution for filling the traps with picolitre volumes. Polypico technology has also been exploited in many ways including to deposit substrate for XFEL experiments, loading grids for automated sample delivery both at Diamond and XFELS, high speed filling of TEM grids for CryoEM with the ultimate aim: to supply sample directly on demand at both Synchrotrons and XFELS. The levitation methodology has already proven successful on a number of beamlines with structure solution of lysozyme and insulin demonstrated. These experiments have been carried out utilising an acoustic methodology known as 'Tinylev'where the focusing of the transducers to create the areas of high and low pressure is achieved mechanically, allowing for simplification of the control/driver electronics. Greater understanding of the stability of the drops contained within these traps has also recently been characterised. Exciting opportunities to explore levitating sample in multiple axis motion is being facilitated by a system developed at UCL called the Acoustofab. Along with this, a Tinylev-type system is also being developed that will use transducers that operate at 300KHz as opposed to 40KHz which will facilitate levitating samples orders of magnitude smaller, a priority for minimising sample consumption.

I plan to submit also conference proceedings

Yes

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