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Adeline Haobing Wang, Rebecca Brown, Julia Bryant, Sergio Leon-Saval, "Hexabundle optical fibre imaging devices for the Hector instrument," Proc. SPIE 11203, Advances in Optical Astronomical Instrumentation 2019, 1120317 (3 January 2020); doi: 10.1117/12.2539992

Event: ANZCOP, 2019, Melbourne, Australia

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Keywords: hexabundles, integral field units, Hector, optical fibres, HF etching, focal ratio degradation

1. INTRODUCTION

Hector[1,5] is the next dark-time instrument to be commissioned on the Anglo-Australian Telescope (AAT) and will include 21 IFUs called hexabundles[2–4,6] that will sit on the 2-degree top end. These hexabundles are bundles of fibres that are packed in a regular hexagonal array. They are built in sizes of 37, 61, 91, 127, and 169 fibres. The distribution of sizes of hexabundles was calculated to maximise the efficiency of the galaxy survey. The Hector hexabundles have been optimised for this instrument. Their regular hexagonal packing has been developed to improve data reduction accuracy, and the fibres have had a short length of their cladding etched in order to pack them as tightly as possible without reducing the optical quality of the devices.

2. FIBRE ETCHING AND THE 169-CORE HEXABUNDLE

The production of the hexabundles involves accurate etching of the cladding on these fibres for the short length that is packed into the front face of the device. The cladding is etched to a thickness of 5um, which means that the fibre cores can be packed extremely closely. Due to this process, the fill fraction (or percentage of the bundle face that is fibre core and can capture light) is 75%. These hexabundles will have 50% more light capturing power than any other fibre IFU used in astronomical galaxy surveys.

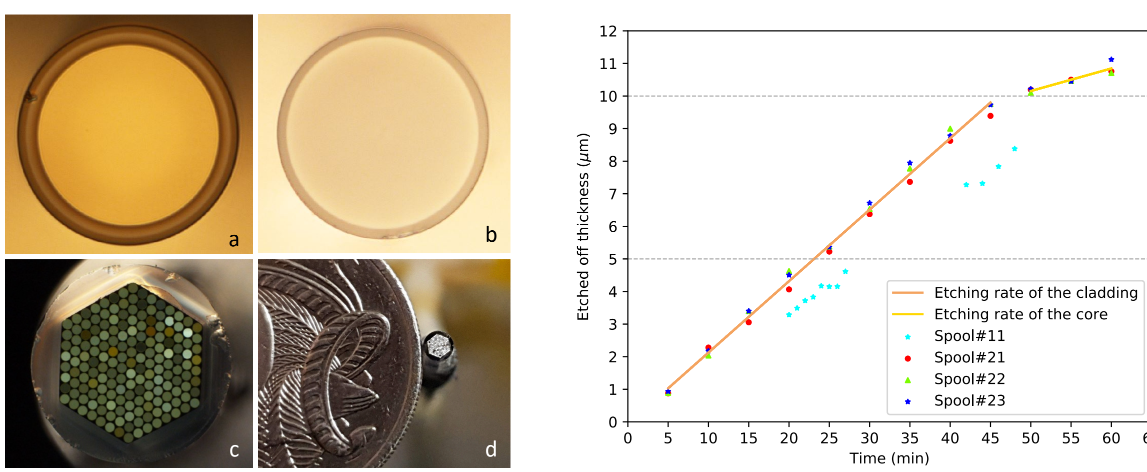

Figure 1: Single optical fibres (top left) used to make the 169-core hexabundle (bottom left) as discussed in the text. Right: Fibres from Spool#11 are made with PCVD+POVD which have a slower etching speed.

The fibres that are used in Hector are WFNS103/123/250 with double acrylate cladding, made by CeramOptec. The light acceptance cone is 0.22NA which is in correspondence with the light from the AAT. Figure 1.a shows the cross section of an fibre under the microscope. The outside dark ring is the fibre cladding and the large area of circle inside the cladding is the fibre core. Light within the acceptance cone is guided by total internal reflection. While conventional theory suggests the cladding thickness should be 10λ, we have found suitable performance in these devices from cladding only 5μm thick.[4]

Advances in Optical Astronomical Instrumentation 2019, edited by Simon Ellis, Céline d'Orgeville, Proc. of SPIE Vol. 11203, 1120317 · © 2020 SPIE · CCC code: 0277-786X/20/$21 · doi: 10.1117/12.2539992

The fibre etching was done at the University of Sydney in collaboration with the Australian National Fabrication Facility (ANFF). A diluted 20% concentration solution of Hydrofluoric acid (HF) was used in a custom designed jig to ensure each fibre was etched evenly across its diameter and along the required length. Figure 1.b shows an etched fibre. Its cladding diameter is etched from 123μm to 113μm, with an etching time of 22 minutes 40 seconds, at a consistent temperature of 20 degrees Celsius.

The etching process uncovered a disparity in some of the manufactured fibres. It was found that the 100km of purchased fibre was made using two different methods. One kind of fibre was entirely deposited using Plasma Chemical Vapor Deposition (PCVD). For the other kind of fibre, its first layer was deposited with PCVD and the second layer using Plasma Outside Vapor Deposition (POVD). While this did not change the optical performance of the fibre, it resulted in a slower etching speed for those made using the latter method (See Figure 1(right)). Once etched, the fibres are fused into the hexabundles using our glass fibre processing units. Figure 1(c and d) shows a hexabundle with 169 fibres next to a 10 cent piece. The entire bundle is just under 2mm wide.

3. FRD TEST AND RESULTS

An important part of collecting more photons on each of the galaxies is to build hexabundles with low focal ratio degradation (FRD). Bad FRD means that the light cone into the fibre comes out much larger and therefore some light is not captured by the spectrograph. We built a complex setup and wrote corresponding code to accurately assess the FRD in the hexabundles we build, therefore the process for making hexabundles can be continually optimised until there is no additional FRD. This is important to the Hector throughput and the amount of light we will get from the galaxies.

We first characterised the performance of the optical fibre delivered from Ceramoptec and confirmed that it had excellent performance, matching the requirement ordered. Tests of the first prototype hexabundles showed the FRD of the inner row cores agree with the bare fibre performance within errors but the outer row cores showed some degradation. The capillary outside around the cores may exert pressure on the outer row cores increasing the FRD. After the first hexabundle, we have further optimised our hexabundle fusing method and a full detailed analysis of the FRD properties is in Wang et al., in prep.

4. CONCLUSIONS

A new updated method for fusing hexabundles has been developed for the Hector instrument. These prototype devices are demonstrating excellent FRD and throughput. Further testing will confirm the performance of the full batch of devices that will be deployed on Hector.

ACKNOWLEDGMENTS

Parts of this research were supported by the Australian Research Council Centre of Excellence for All Sky Astrophysics in 3 Dimensions (ASTRO 3D), through project number CE170100013 and through ARC LIEF grants LE150100144, LE170100242, LE190100018. AHW would like to acknowledge support from a CSC PhD scholarship. JJB acknowledges support from an ARC Future Fellowship FT180100231. We acknowledge the assistance of Dr Chris Betters with some of the equipment in the SAIL/AAO-USyd laboratories.

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