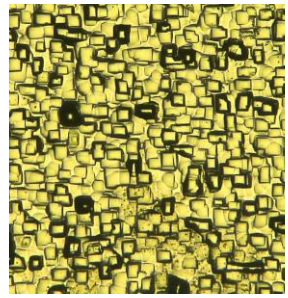
LASER SUBDIVISON of the GENESIS CONCENTRATOR TARGET SAMPLE 60000. H. V. Lauer Jr.[1], P.J. Burkett[2], M.C. Rodriguez[3], K. Nakamura-Messenger[2], S. J. Clemett[4], C.P. Gonzales[2], J.H. Allton[5], K.M. McNamara[5], T.H. See[1], [1]ESCG/Barrios Technology, Houston, TX 77058, howard.v.lauer@nasa.gov, [2]ESCG/Jacobs Technology, Houston, TX 77058, [3]ESCG/Geocontrol Systems, Houston, TX 77058, [4]ESCG/ERC Inc., Houston, TX 77058 USA, [5]NASA/Johnson Space Center, Houston, TX 77058.

Introduction: The Genesis Allocation Committee received a request for ~ 1 cm^2 of the diamond-like-carbon (DLC) concentrator target for the analysis of solar wind nitrogen isotopes. The target consists of a single crystal float zone (FZ) silicon substrate having a thickness on the order of 550 μm with a 1.5-3.0 μm-thick coating of DLC on the exposed surface. The solar wind is implanted shallowly in the front side DLC.

The original target was a circular quadrant with a radius of 3.1 cm; however, the piece did not survive intact when the spacecraft suffered an anomalous landing upon returning to Earth on September 8, 2004. An estimated 75% of the DLC target was recovered in at least 18 fragments. The largest fragment, Genesis sample 60000, has been designated for this allocation and is the first sample to be subdivided using our laser scribing system

Laser subdivision has associated risks including thermal diffusion of the implant if heating occurs and unintended breakage during cleavage. A careful detailed study and considerable subdividing practice using non-flight FZ diamond on silicon, DOS, wafers has considerably reduced the risk of unplanned breakage during the cleaving process. In addition, backside scribing reduces the risk of possible thermal excursions affecting the implanted solar wind, implanted shallowly in the front side DLC.

Materials and Methods: In order to minimize the possibility of unintended breakage of the actual target wafer during subdivision, a careful detailed study involving numerous laser scribing plans was undertaken. In all cases though, the laser scribes were done along a major crystallographic plane in order to maximize the probability of a successful cleave. It turns out that identification of the major axes of a FZ silicon wafer is easily done using a > 500x optical image of the wafer. Our polished Z-axis oriented non-flight single crystal FZ silicon wafers present a pattern of oriented squares along the specimen's primary crystallographic planes when viewed at high magnification using an optical microscope. In other words, the 100 and 010 directions are easily picked out using the axes defined by the oriented square patterns. Figure 1 shows such an image.



→ X ↑Y

Figure 1: 700x optical micrograph showing the observed square patterns on a non-flight z-axis oriented FZ silicon wafer. Looking carefully at the image one can easily determine the 100 and the 010 directions on the wafer.

Results from numerous scribing trials indicated that we would have ~100 % cleaving success if we adopted the following scribing plan. Orient the wafer on the laser cutting stage such that the 100 and the 010 directions of the wafer were parallel to the corresponding X and Y directions of the cutting stage. The laser was programed to scribe 31 lines of the appropriate length along the Y stage direction. The scribe lines were separated by 5μm in the X direction. The laser parameters were set as follows. (1) The laser power was 0.5 watts. (2) Each line consisted of 50 passes with the Z position being advanced 5μm per pass. (3) There was a built-in wait time of 30 seconds before scribing the next line to allow for wafer cool down from any possible heating via the laser. After the laser was finished scribing, the oriented wafer and mounting plate was removed from the cutting stage and placed on the "stage area" of a lighted binocular microscope. This allowed ablated silicon from the laser scribing could be "teased" out of the "scribed" pattern using an ultrasonic aided sharpened micro-tool. The loosest Si "fluff" was then removed (vacuumed and or brushed) from the wafer surface. After all of the ablated Si was removed from the scribe channel, the mounted wafer was then repositioned in exactly the same orientation on the laser stage. The laser was focused using the bottom of the wafer channel and the 31 line scribing pattern described above reprogrammed using the Z position of groove bottom as the starting Z value instead of the top wafer surface previously used. After the laser completed the second set of scribes, the ablated material was removed from the groove using the technique described above for the initial set of scribes.

The wafer was remounted on the stage using exactly the same orientation as before. Again the laser was focused on the bottom of the groove. This time however, it was programed to scribe only one line down the exact center of the channel. The final scribe line consisted of 100 passes with a Z advance of 5µm per pass and the laser power set at 0.5 watts. We found that using the above scribing plan yielded a ~100 % cleaving success rate on non-flight FZ silicon wafers ~ 550µm thick with a scribe length of < 4cm. Our test results gave us confidence that we would be successful "cutting" the flight target concentrator piece as per the allocation request.

Figure 2 shows the front side view of the DOS 60000 target sample with the position of the proposed scribe lines. The requested allocation section is shown in green. Note the actual scribing on the wafer is done on the back side.

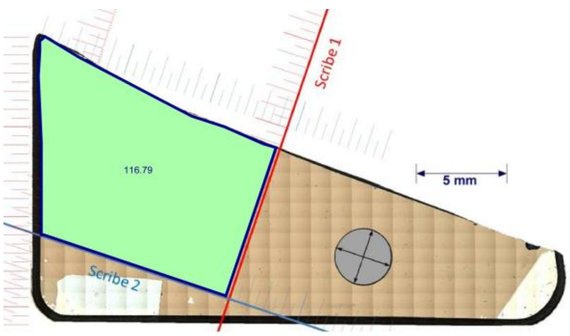


Figure 2: (Front side view) Placement of scribe lines 1 and 2 on the DOS 60000 fragment resulting in an area of ~1.15 cm^2. Note the crystallographic orientation shown on the diagram.

The actual mounting of the sample took place in the Genesis clean room with all of the members of the cutting Tiger Team suited up in full body clean room apparel. In order to minimize any possible contamination of the target piece during laser scribing, the target was mounted face down on the front surface of a pristine silicon wafer. The target piece was held in place on the Si wafer using a carefully selected set of Si blocking pieces of uniform thickness (~550 µm).The blocking pieces were attached to the Si substrate with special clean room tape. The tape was applied to the blocking pieces such that it would not be impacted by the laser during scribing, nor was it in close proximity to the target piece. Prior to attaching the target piece to the Si wafer, the Si wafer was mounted on a clean stainless steel plate using low tack double sided tape.

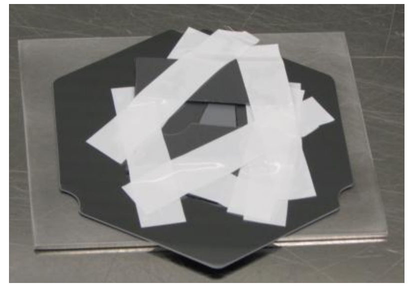


Figure 3: This photo shows the mounted target DOS 6000 (light gray region in the center of the photo) wafer before it was transported to the laser lab for scribing.

Results: The mounted target shown in figure 3 was boxed up inside a clean Polar Ware container for transport to the laser lab.

The mounted target was removed from the transport container and placed on the laser's vacuum stage. The stage was adjusted such that the target was in position for implementing scribe 1 using the Y direction of the stage. The wafer was scribed using the scribing plan discussed above. After each set of scribes 31 lines, the mounted target was boxed up and returned back to the Genesis anteroom to clean out the Si "fluff". Once the entire process on scribe 1 was completed, the target was un-mounted in the Genesis anteroom and cleaved using the cleavenator[1]. The appropriate target piece was then remounted as described above and scribe 2 was done in a manner similar to scribe 1 discussed previously. When the entire scribe 2 processes was finished, the target was un-mounted in the Genesis anteroom and cleaved between two glass plates[1]. Figure 4 shows the target piece after it was successfully cleaved. The requested allocation piece has been delivered to the requestor.

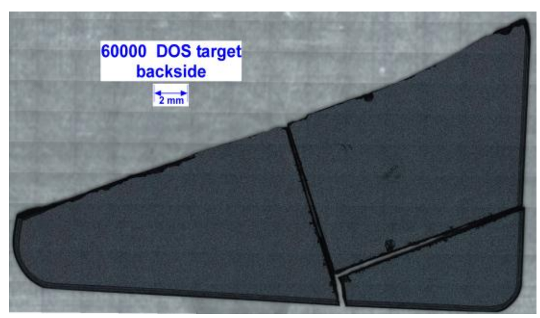


Figure 4: This photo shows the target wafer after cleaving scribe lines 1 & 2. The requested allocation piece is in the upper right hand section of the photo.

References: [1] See, T. H, et.al (2012) ESCG-3200-12-ARG-MEMO—0001 "Recommendations to the JSC Curator and Genesis CAPTEM Committee on Subdividing the Genesis DOS 60000 Concentrator Wafer.