

Supplementary Information

Chemical And Morphological Evolution of Hybrid Conversion Coatings in Low-Earth Orbit Space Environment

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Figure S1 Certificate of the mission

Table S1 Fitting parameters for Cu 2p_{3/2} XPS in Cu10 and Cu20.

| Sample group | Conditions | Components | Fitted Cu 2p _{3/2} (eV) | Full width at half maximum (FWHM, eV) | Residual standard deviation | Peak Area (CPS·eV) | Atomic concentration (%) |
|--------------|------------|----------------|----------------------------------|---------------------------------------|-----------------------------|--------------------|--------------------------|
| Cu 10 | Pristine | Cu(0) or Cu(I) | 932.7802 | 2.17361 | 0.8 | 49192.8 | 37.23 |
| | | Cu(II) | 933.8110 | 3.53883 | | 41075.7 | 31.06 |
| | Twin | Cu(0) or Cu(I) | 933.3420 | 2.45712 | 0.9 | 68565.8 | 50.28 |
| | | Cu(II) | 935.6617 | 2.21932 | | 25596.8 | 18.73 |
| | ISS | Cu(0) or Cu(I) | 932.8000 | 1.98000 | 1.8 | 17213.1 | 10.52 |
| Cu(II) | 933.8000 | 2.84000 | 66855.7 | 40.81 | | | |
| Cu 20 | Pristine | Cu(0) or Cu(I) | 932.7028 | 2.50424 | 0.8 | 68002.9 | 53.21 |
| | | Cu(II) | 934.4961 | 2.45102 | | 21173.3 | 16.54 |
| | Twin | Cu(0) or Cu(I) | 932.6605 | 3.16467 | 0.9 | 39114.4 | 10.77 |
| | | Cu(II) | 934.8449 | 2.36298 | | 15185.2 | 4.17 |
| | ISS | Cu(0) or Cu(I) | 932.3223 | 2.81223 | 0.8 | 12606.0 | 22.09 |
| Cu(II) | 934.2101 | 3.57427 | 28047.7 | 49.05 | | | |

Table S2 Coating depth for each sample condition

| Sample Conditions | Thickness (nm) |
|-------------------|-----------------|
| Cu 10 ISS | $\sim 38 \pm 2$ |
| Cu 20 ISS | $\sim 48 \pm 2$ |
| Cu10 Twin | $\sim 37 \pm 2$ |
| Cu20 Twin | $\sim 49 \pm 2$ |

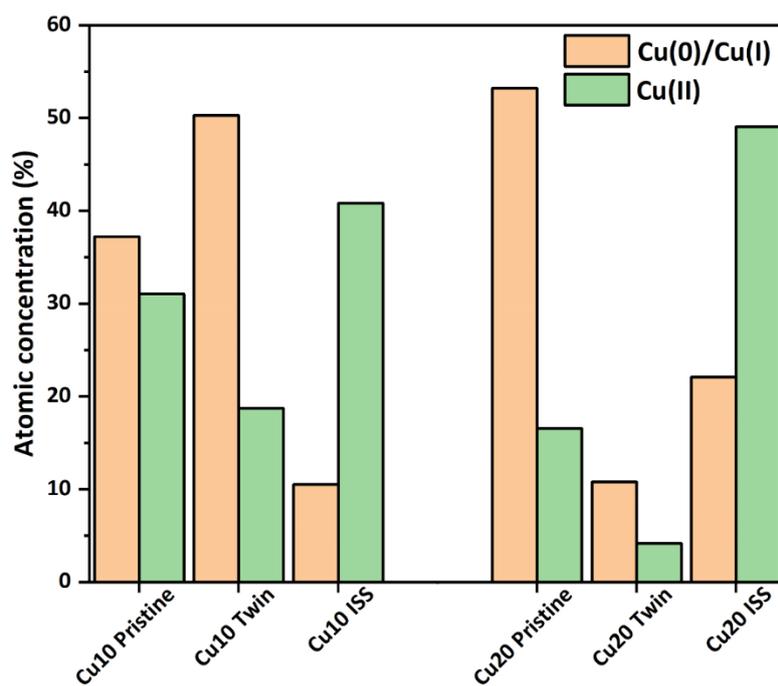


Figure S2 Atomic concentration obtained using XPS (%) for all the sample conditions for Cu species

Table S3 Fitting parameters for Zr 3d_{5/2} XPS in ISS Cu10 and Cu20

| Sample group | Conditions | Components | Fitted Zr 3d _{5/2} (eV) | Full width at half maximum (FWHM) (eV) | Residual standard deviation | Peak Area (CPS eV) | Atomic concentration (%) |
|--------------|------------|------------|----------------------------------|----------------------------------------|-----------------------------|--------------------|--------------------------|
| Cu 10 | ISS | Zr (III) | 180.93 | 1.61232 | 0.9 | 5888.8 | 8.84 |
| Cu 20 | ISS | Zr (III) | 180.91 | 1.91232 | 0.8 | 5883.9 | 10.74 |

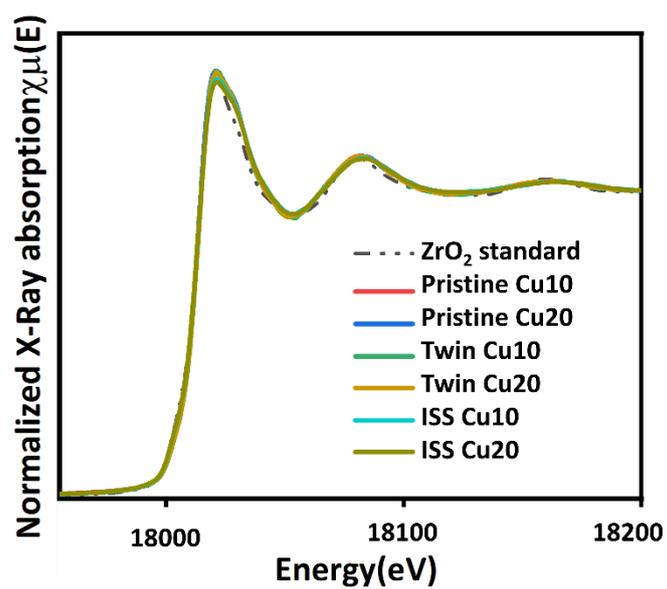


Figure S3 XANES of various samples for Zr K-edge