**Supporting Information**

**Taking advantage of glass: Capturing and retaining** **of** **the helium gas on the moon**

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**1. The helium volume density**

To estimate the mass of helium in Lunar regolith, we calculate the helium density in the bubbles by1:

$n\_{He}=\frac{I\_{He}}{I\_{ZIP}σ\_{He}d}$ (S1)

Where *n*He is the helium volume density (in He/nm3), *I*He is the integrated signal of helium, *I*ZIP is the integrated intensity of the elastic peak. *σ*He=5.9×10-6 nm2 is the cross section for the He 1s-2p transition2, and the h is the local thickness at the pixel position of the analyzed He nanovolume.

Fig. S1a shows a representative helium bubble with *d*≈20 nm or *r*≈10 nm, the corresponding EELS spectrum is shown in FigS1b. The Gaussian fitting can remove the bulk plasmonic contribution and then the EELS spectrum of bulk (the red Gaussian fitting line) is subtracted by the EELS spectrum of sample (the blue line), as shown in Fig. S1b. Based on the equation S1, the density of helium in this bubble is about *n*He=133 He/nm3. On the other hand, the density of helium of four representative bubbles was calculated carefully, the values are listed in Table S1. We can find that the corresponding estimated helium volume density lies between 50 and 192 He/nm3.



**Figure S1. (a) The dark-filed image of representative helium bubble under room temperature. (b) The EELS spectrum (red line), Gaussian fitting data (black line) and the subtracted line of He (blue line).**

**Table S1. The helium volume density *n*He for four representative bubbles**

|  |  |
| --- | --- |
| *d* (nm) | *n*He (He/nm3) |
| 15.77 | 133 |
| 21.75 | 130 |
| 22.39 | 192 |
| 20.45 | 50 |

**2. The pressure of He**

Upon the temperature and helium volume density, we can estimate the pressure by3,4:

$P\left(n\_{He}\right)=an\_{He}[\left(1-νn\_{He}\right)×\left(1+νn\_{He}-2ν^{2}n\_{He}^{2}\right)+n\_{He}b\left(1-νn\_{He}\right)^{2}+c\left(3-2νn\_{He}\right)ν^{3}n\_{He}^{2}-50(1-νn\_{He})ν^{2}n\_{He}^{2}]$ (s2)

where *a*=0.0138062*T*, *b*=170/*T*1/3-1750/*T*, *c*=0.1225*T*0.555 and *n*He is expressed in (Å-3). In Fig. S2a, the pressure of bubbles versus *n*He is given under *T*=300 K, the red shaded area corresponding the pressure of experimental data.

On the other hand, the bubble pressure is proportional to the reciprocal of the radius of bubble 1/*r* when the bubble deforms the matrix elastically1,5:

$P\left(n\_{He}\right)=\frac{2γ}{r}$ (s3)

The surface energy of TiO2 is 0.95 Jm-2 6. The red shaded area corresponding the pressure of experimental data, as shown in Fig. S2b.



**Figure S2. (a) The pressure change with the helium density. (b) The pressure as a function of the bubble radius. The red shaded area represents the pressure range of experimental data.**

**3. The reserves of He**

In the Fig 2, the thickness of amorphous layer is about *h*al=50 nm, the length is about *L*=230 nm and there are 3 bubbles with the radius *r*≈10 nm. It is reasonable to assume that there are 9 bubbles in the volume *V*a=*L*×*W*×*h*al=2.645×10-21 m3, and the ratio of bubble’s volume to amorphous layer volume is about 1.43%. If we assume that the superficial area of amorphous layer equals to that of the ilmenite *S*ilmenite=(3.7+7.5)×10/2=56 μm2, the ratio of amorphous volume to ilmenite volume can be calculated by *h*al/*h*ilmenite=0.5%. Therefore, the ratio of bubble’s volume to ilmenite volume is about *C*v=7.12×10-5. On account of the surface area of lunar *S*=3.79×1013 m2 and the thickness of the regolith changing from *h*=5 m to *h*=10 m, we can obtain the volume of regolith *V*regolith=(1.9-3.8)×1014 m3. Further, the volume of all the bubbles can be expressed by:

$$V\_{bubbles}=0.06C\_{v}\frac{ρ\_{regolith}V\_{regolith}}{ρ\_{ilmenite}}$$

where *ρ*regolith=1500 kg/m3, the percentage of ilmenite is about 6% 7 and the volume of bubbles *V*bubbles=(2.5-5)×108 m3.

Given that the helium volume density *n*He=50-192He/nm3, it yields a total mass of helium in the bubbles about (8.4-64.5)×1010 kg.

Upon the ratio of 3He/4He is about 4×10-4,8 the mass of 3He in the bubbles is about (3.4-26)×107 kg.

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