Cell–substrate interactions lead to internalization and localization of layered MoS2 nanosheets

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Supporting Information:

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Figure S1: AFM statistics histograms

Atomic force microscopy was used to compare to statistics obtained from Raman mapping. Statistics from AFM shown in Figure S1.

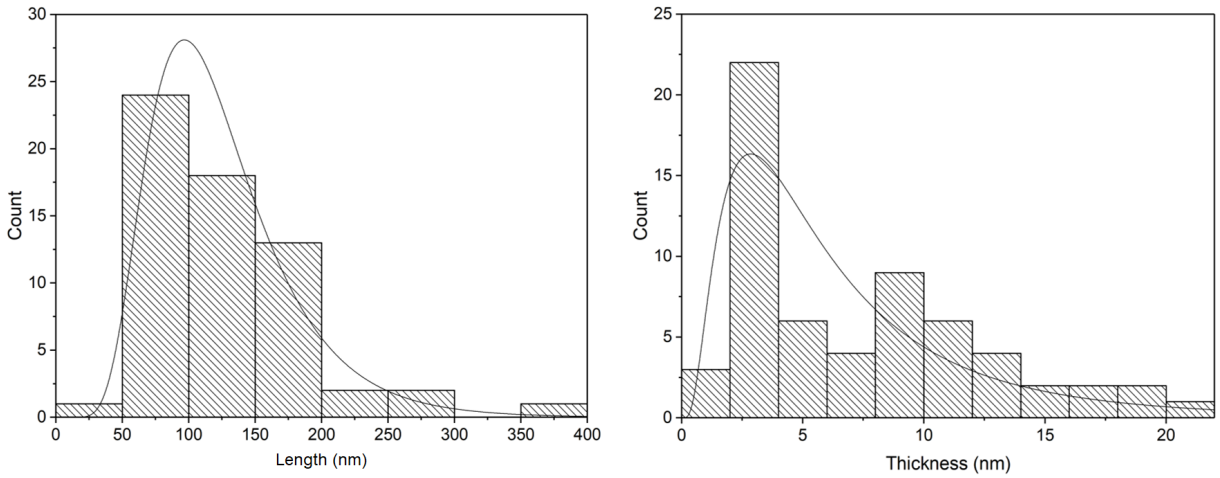

Figure S1: AFM statistics histograms for MoS_2 nanosheets showing length and thickness data.

Figure S2: Optical images of U2OS cells on MoS_2 substrates

Additional optical micrographs are included here to supplement those shown in Figures 2b, 2e and 2f.

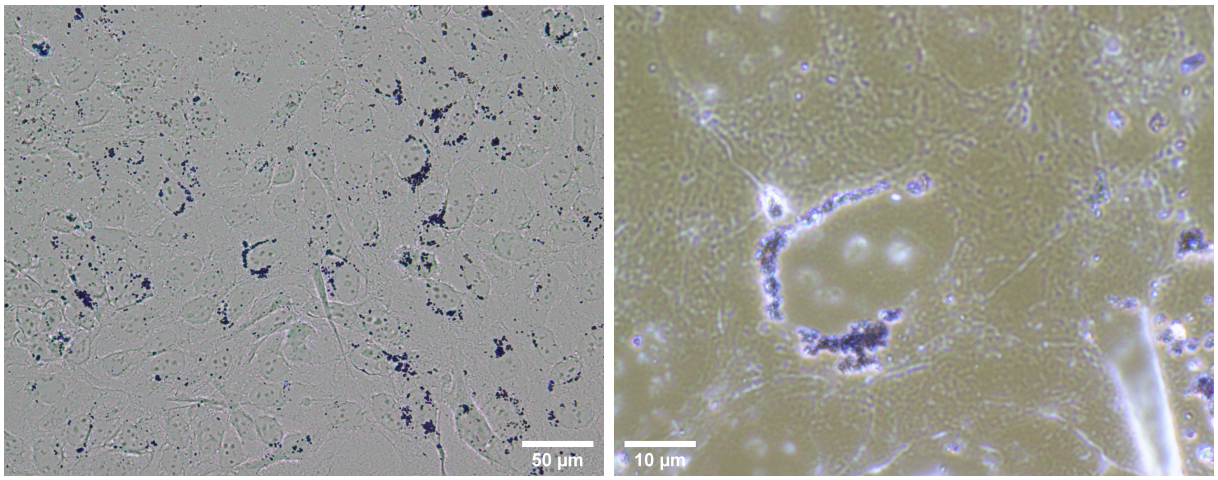

Figure S2: Optical micrographs showing U2OS cells after 7 days growth on a MoS_2 substrate.

Figure S3: Raman volume map

By mapping the peak intensity of the 405 cm^{-1} A_{1g} mode, and using Raman volumetric mapping, it is possible to determine detailed spatial information for the nanosheet within the cell. Combining multiple overlapping steps gives a z-resolution of < 1 μm, and therefore it is possible to confirm the difference between material internalized within the cell and that above or below the cell. This is shown in Figures 3d, 3e & S3.

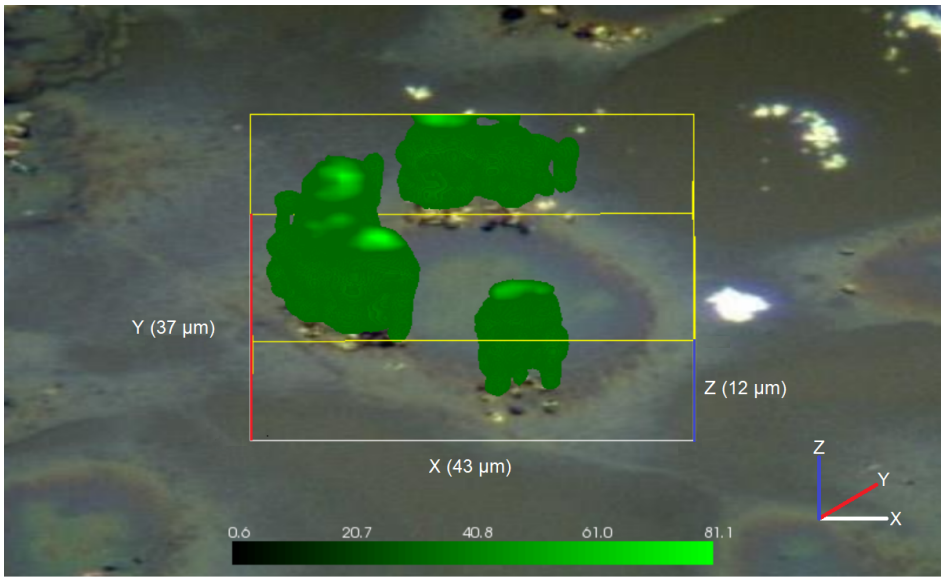

Figure S3: Raman volume map of the A_{1g} Raman mode for cells after 7 days growth on a MoS_2 substrate.

Figure S4: 2D Raman map

Raman mapping confirms our observations from optical microscopy, showing that the nanosheets are largely internalized in the region around the nucleus (the endoplasmic reticulum), with some material identified in the cytoplasm. This is seen in Figures 3a, 3g & S4.

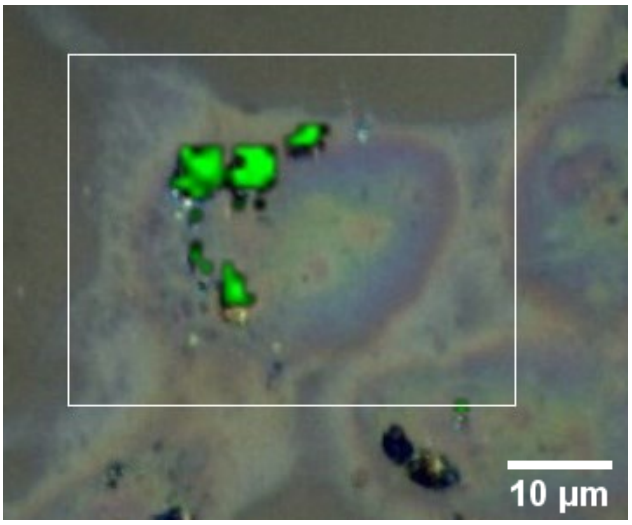

Figure S4: 2D Raman map of the A_{1g} mode showing MoS_2 localized around the nucleus.

Figure S5: Raman spectrum of internalised material

As discussed in the paper, Raman spectroscopy was used to ascertain whether the internalization process modified the MoS_2. Results shown in Figure S5 shows that there is little to no change to the material.

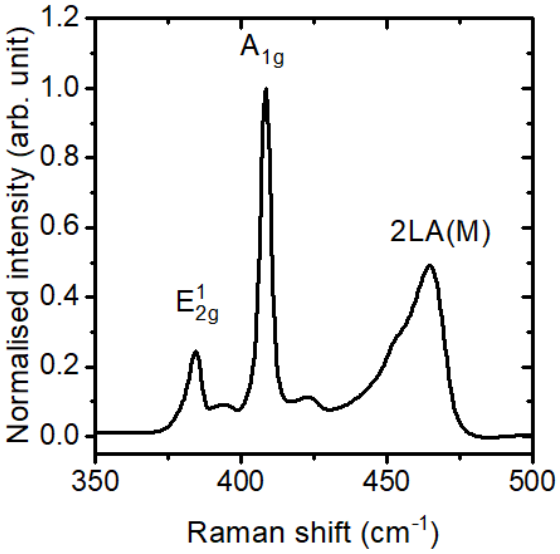

Figure S5: Raman spectrum from MoS_2 internalized in cells after 7 days growth on a MoS_2 substrate.

Figure S6: Cells grown in 20 % Nystatin solution

As discussed in the paper, Nystatin is used as an inhibitor for the caveolin pathway. In the present study, the use of nystatin did not alter the U2OS cell accretion of the MoS_2, but significantly reduced internalization was observed, implying that this uptake pathway is dominant for MoS_2. There was some evidence of MoS_2 within the cytoplasm, most likely in lysosomes through passive diffusion or alternate endocytic pathways. This fits with the expected uptake mechanism for transition metals in a mechanotransduction substrate response. Typical optical micrographs of the U2OS cells grown in 20 % Nystatin solution are shown in Figure S6.

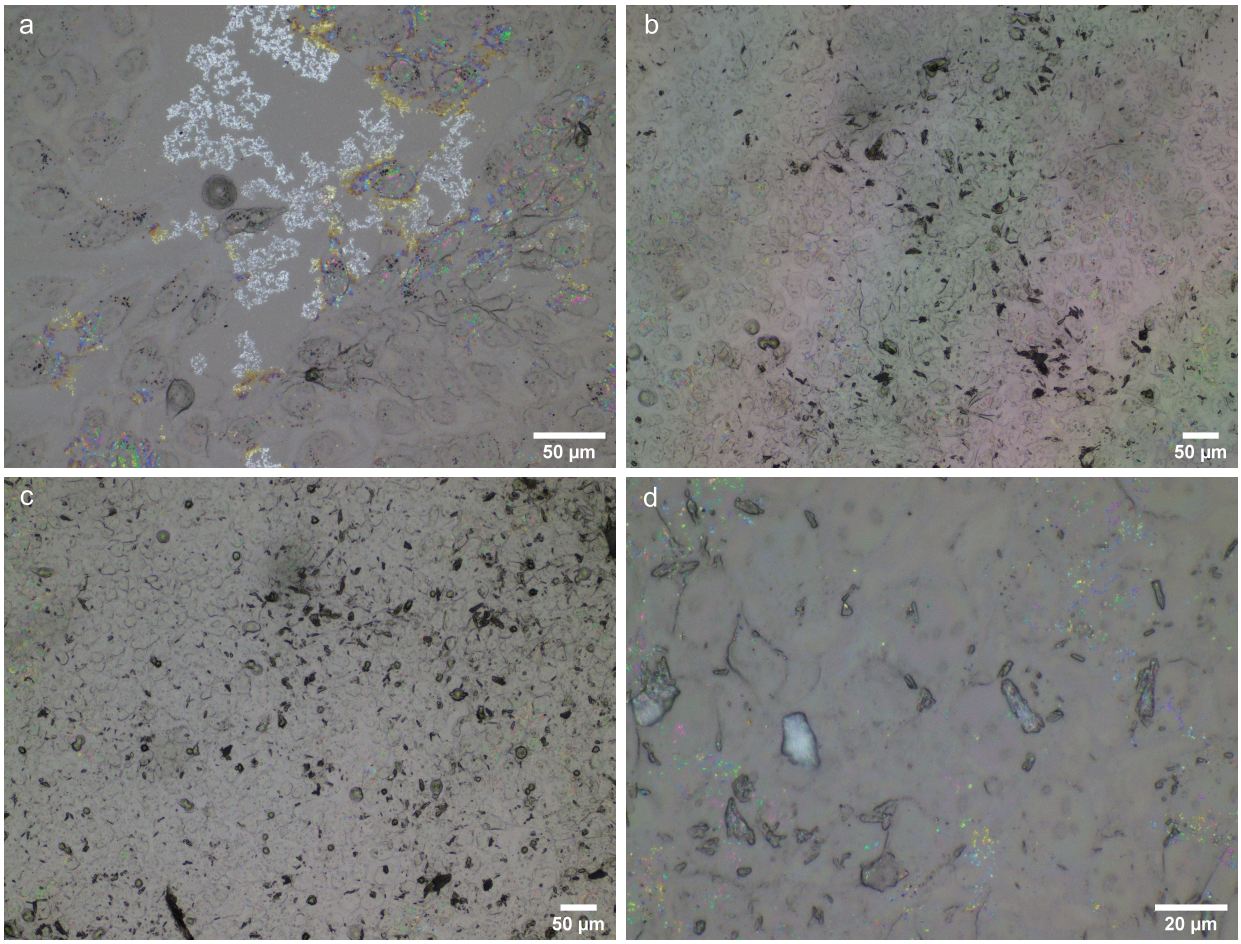

Figure S6: a) U2OS cells grown on MoS_2 substrates, no Nystatin solution (control). b–d) U2OS cells grown on MoS_2 substrates with 20 % Nystatin solution to limit caveolin uptake.