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Nitrogen trapping in amorphous ice and its transformation into clathrates

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Nitrogen-bearing clathrates, possibly mixed as gas hydrates also containing CO, H2, and CO2, are potentially important astrophysical constituents as they might take part in the formation of nebulae, comets and might have participated in the formation of the outer planets in the solar system.(1),(2)
The formation of clathrates in the solar system is often associated with vapor deposited amorphous solid water (ASW).(3)
Highly porous ASW has specific properties of adsorption, sintering and gas enclosure. It can enclose large amounts of gas which cannot be pumped off in vaccuo. The enclosed gas enables the necessary pressure build-up for transformation of ASW into a crystalline form as temperature increases.
In the present work, ASW is obtained by vapor deposition at low temperature (~80 K). Nitrogen gas is admitted and the sintering process is observed between 80 K and 140K, as indicated by the removal of the Raman peak attributed to dangling OH. Formation of clathrates is characterized spectroscopically upon heating above 160K. The signature of enclosed nitrogen trapped in micropores of ASW and clathrate structure can be discriminated by high resolution Raman spectroscopy.

References:
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(2) Lunine, J.; Choukroun, M.; Stevenson, D.; Tobie, G. Titan from Cassini-Huygens; 2009.
(3) Hallbrucker & Mayer, Icarus, 90, 176-180, 1991

Significance statement

Formation of clathrates from amorphous solid water are of significant interest in astrophysical context, as they might take parts in the formation of nebulae, comets or small planets. Laboratory studies are relevant to study the ASW to clathrate transformation using vibrational spectroscopy of the guest trapped into the solid structure

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