How adhesive force measurements of gas bubbles can help to achieve an excellent performance of direct hydrazine fuel cells.

Direct liquid-feed fuel cells (DLFCs) have attract more and more attention because of their low-cost, high power densities and clean energy. They have a bright future in mobile and stationary applications. DLFCs directly converse chemical energy into electrical energy by the oxidization of liquid fuels. Numerous nanostructured catalysts on the electrodes have been explored to improve the energy conversion efficiency. However, the behaviour of the gas products (such as N_2 and CO_2) on the electrode surfaces received very little attention, which is also critical for achieving a better performance of the DLFCs especially at high reaction rates. The reason for this is that gas bubbles that accumulation on the surface will not only block the catalyst sites but also cause a high pressure in the liquid flow area that limits the fuel crossover. It has been reported that the surface architecture can significantly affect the gas bubble adhesion behaviour. Recently, Jiang's group discovered that a discontinuous three phase (solid–liquid–gas) contact line (TPCL) which will be present on micro-/nanostructured surfaces with high surface porosity can notably reduce the gas products adhesion force, leading to enhanced electrocatalytic performance with accelerating gas evolution behaviour even at high reaction rates. As reported, the N_2 evolution in hydrazine oxidation reaction (HzOR) on the electrode surface that resulted in the severe bubble adhesion is one of the biggest issues in direct hydrazine fuel cells (DHFCs). Recently, they reported that by nanostructuring inexpensive Cu foils, highly efficient 3D nanostructured Cu electrodes with "superaerophobic" characteristics result in an excellent performance (**Figure 1**).

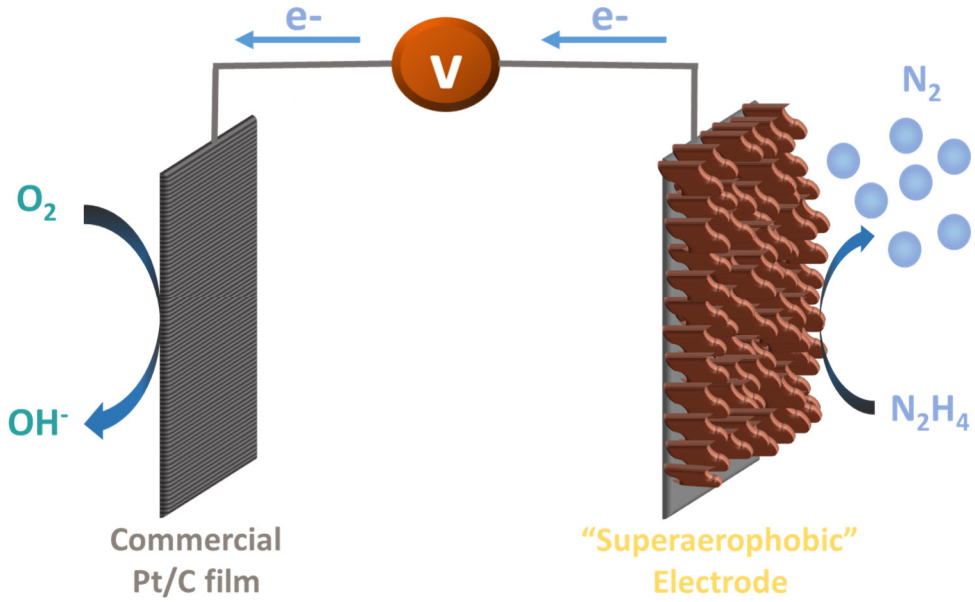


Figure 1. *application of nanostructured Cu films for DHFCs.*

In this research, adhesive forces of the gas bubbles on planar and nanostructured films were measured. **Figure 2** illustrates that the adhesion force of the gas bubble on the flat Cu foil was up to 80 µN (Figure 2a), however, a negligible adhesion response was shown on the 3D nanostructured Cu film (Figure 2b). This indicates that extremely small bubble adhesive forces were afforded and more catalytically active sites could be provided on nanostructured Cu film.

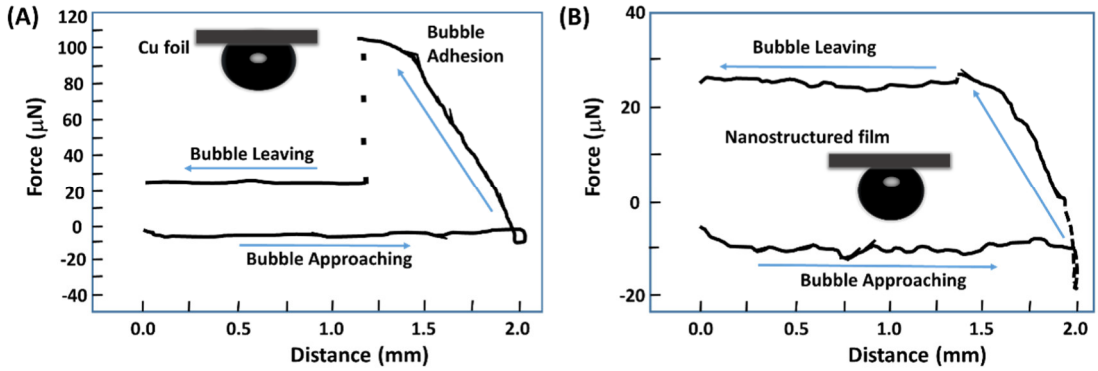
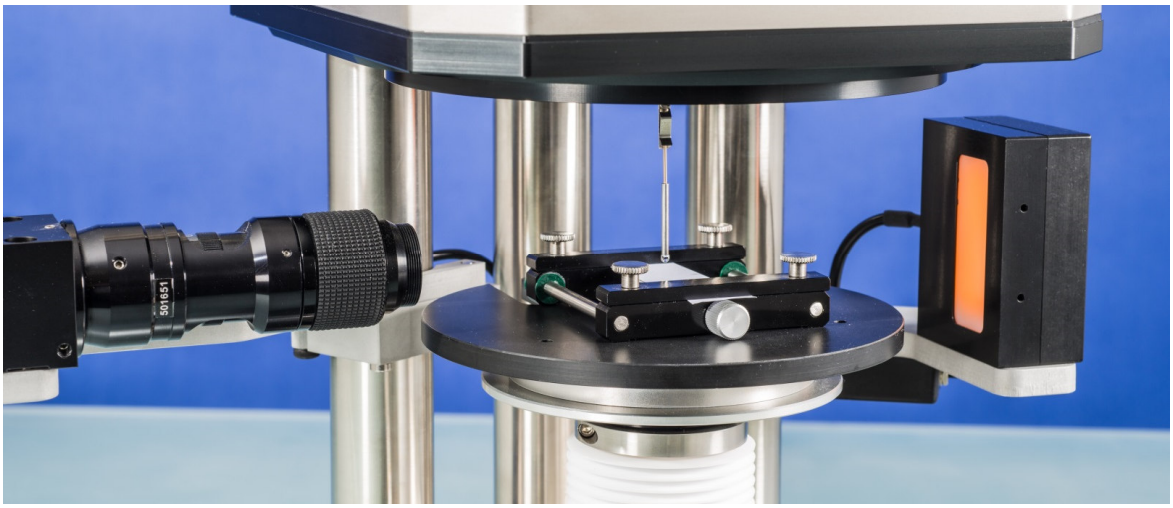


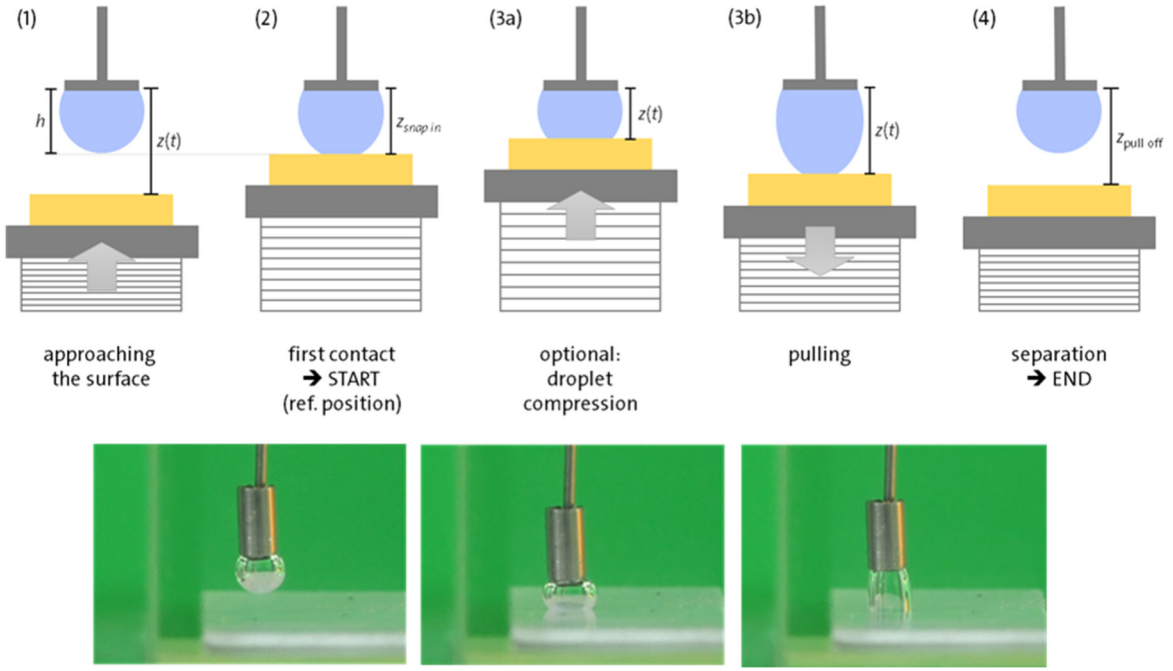
Figure 2. *Adhesive forces and under liquid contact angle measurements of gas bubbles on planar (a) and nanostructured Cu films (b).*

Adhesive Force Measurements of gas bubbles under water with DCAT 25

Adhesive forces of liquids in air phase or of gas bubbles under liquid phase can be analysed with the Dynamic Contact Angle measuring devices and Tensiometer DCAT 25 with video upgrade.



This system combines a force measurement to determine the force of adhesion and an optical system to determine the area of contact between the liquid/gas and solid phase for each force that is measured. Like this a force per area can be determined. The measurement procedure involves a liquid or gas bubble being pushed onto a solid substrate under air or liquid and being pulled of from it again.



It was further confirmed by a digitally recording process that the average gas bubbles releasing size on Cu foil was around 150 µm (diameter) and only one big bubble was observed in a certain area, while the bubbles left quickly before they became bigger than 20 µm (diameter) on 3D nanostructured films and more than 10 small bubbles were observed in a certain area. In addition, contact angle measurements of gas bubbles under liquid on the two surfaces were carried out. The contact angle (CA) on the flat surface (138.7 ± 2.8) and nanostructured Cu film (169.6 ± 1.3°) also showed that the nanostructured Cu film is a "superaerophobic" surface (inset of Figure 2a and 2b). All these findings firmly demonstrate that it is very important to use highly rough surfaces for efficiently releasing gas bubble.

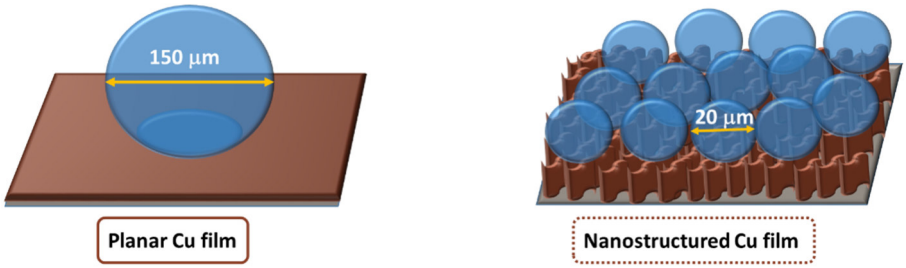


Figure 3. *Releasing size of gas bubbles in a certain area on planar (a) and nanostructured Cu films (b).*

Fuel cell performance of the nanostructured Cu films was also investigated, demonstrating that the nanostructured Cu film can facilitate a much faster current increases as well as much smaller charge-transfer resistances with a good stability. The study showed that the fuel cell performance was significantly influenced by the efficiency of the gas bubble releasing behaviour.

Overall, 3D nanostructured Cu film was employed to achieve a "superaerophobic" electrode with low gas bubble adhesion force, leading to small size gas bubbles with an efficiently releasing behaviour. The research exhibited an efficient and facile method for resolving the gas adhesion problem that drastically enhances the performance of DHFCs. DHFC with "superaerophobic" electrode have a big potential in green power supply.

The Dynamic Contact Angle measuring devices and Tensiometer DCAT 21 with video system (DataPhysics Instruments GmbH, Germany) was used in this research.

For more information, please refer to the following article:

Superaerophobic Electrodes for Direct Hydrazine Fuel Cells; Lu, Z., Sun, M., Xu, T., Li, Y., Xu, W., Chang, Z., Ding, Y., Sun, X. and Jiang, L. **2015**, *Adv. Mater.*, 27: 2361-2366. doi:10.1002/adma.201500064