Systematic measurement of the pumping properties of a cryogenic surface

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Introduction

The residual gas density in the beam vacuum system of a heavy ion synchrotron is a crucial factor for stable and reliable beam operation at highest intensities. The interaction of the beam particles with the residual gas may cause severe beam loss. In combination with ion impact stimulated gas desorption from the beam pipe, this can lead to a reduced beam lifetime and transmission of the acceleration cycle. Therefore, beam induced pressure rise must be suppressed by the pumping system.

To achieve proper vacuum conditions, the vacuum chambers of SIS100 will act as cryogenic surface pumps. Cryogenic surfaces are able to pump gases according to their saturated vapor pressure (SVP) curves. This process is called cryocondensation. The reachable pressures for all heavy gases are sufficiently low for stable beam operation. The SVP of hydrogen is too high even at a temperature of 4.2 K. If the surface coverage is sufficiently low, hydrogen can be pumped to lower pressures by so called cryosorption \cite{1}. This effect can be characterized by two parameters: The sticking coefficient which is the probability of a gas particle impacting on the surface to be bound. It is directly linked to the pumping speed provided by the cryogenic walls. The mean sojourn time describes how long a particle remains bound to a surface. Both parameters together determine the equilibrium pressure. This pressure as a function of the surface coverages at a specific temperature is called isotherm.

Measurements at cryogenic temperatures

An UHV experiment (see Figure 1) to determine these parameters has been set up. The cold surface is provided as a small stainless steel chamber which is cooled by a cryocooler. So far, measurements in the temperature range from 7.2 to 23 K have been conducted. The lower corner valve remains closed once the cryostat reaches its target temperature. It is adjusted by resistive counter heating of the inner chamber. Subsequently, hydrogen is let into the cryostat through the copper orifice. The gas flow is monitored by two extractor gauges. Its magnitude equals the pumping speed provided by the cryogenic walls. The mean sojourn time describes how long a particle remains bound to a surface. Both parameters together determine the equilibrium pressure. This pressure as a function of the surface coverages at a specific temperature is called isotherm.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{Figure1.png}
\caption{Measurement setup for cryosorption.}
\end{figure}

Figure 2: Preliminary isotherms for H\textsubscript{2} on stainless steel. A coverage of $\approx 2.2 \cdot 10^{15}$ cm\textsuperscript{-2} equals one monolayer \cite{2}.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{Figure2.png}
\caption{Preliminary isotherms for H\textsubscript{2} on stainless steel. A coverage of $\approx 2.2 \cdot 10^{15}$ cm\textsuperscript{-2} equals one monolayer \cite{2}.}
\end{figure}

References

\cite{1} E. Wallén, J. Vac. Sci. Technol., A 14, 1996, p. 2916

[2]