FOREWORD

Although fossil fuels and nuclear power generation will remain the main energy sources for many more years, there is increasing awareness that sustainability is one of the most important challenges for mankind in the near future. Sustainability involves necessarily renewable energy sources and, consequently, new energy production, storage and distribution scenarios.
The inherently intermittent nature of renewable energy sources renders buffering and storage of energy indispensable. At present energy buffering is mainly provided by fossil fuel-generated electricity. This is not possible when intermittent sources represent more than 30% of the total energy sources. It is therefore necessary to look for other energy carriers. Hydrogen is in this context one of the most attractive candidates since it can be integrated in a clean hydrogen-water-hydrogen closed material loop and offers interesting storage and distribution possibilities. Through electrolysis and fuel cells it can also be linked to the other clean energy carrier: electricity.

However, before such a **sustainable hydrogen economy** can become reality, many knowledge gaps need to be bridged. There exist many technical problems, which are connected to the production of hydrogen (both from fossil and sustainable sources), the clean separation of hydrogen from production gas mixtures, the storage of hydrogen and its transport. Besides these technological problems there are also important economic and societal questions concerning for example the management of energy systems, the public risk perception of a hydrogen based economy , and the need of safety systems.

Although the title of this Master course is rather general, the present lecture notes focus on the interaction of hydrogen with metals. The first eight chapters give the basic physical concepts necessary to describe and understand

- the thermodynamics of ab- and desorption of hydrogen in a metal
- the nature of the metal-hydrogen and hydrogen-hydrogen interaction
- the electronic structure of transition metal-hydrides
- the high mobility of hydrogen in metals
- the origin of large isotope effects in phase diagrams, diffusion and superconductivity
- the metal-insulator transition in rare-earth metal-hydrides (switchable mirrors)
- the properties of complex metal-hydrides and alanates

We are convinced that a better fundamental understanding of metal-hydrogen systems is an essential ingredient in the search for better (i.e. lighter, more compact and cheaper) hydrogen storage systems.

The role of metal-hydrides within a sustainable hydrogen economy is described in Chapter IX. Safety aspects related to the use of hydrogen in general and as an energy carrier in particular are treated in Chapter X.

The course Science and Technology of Hydrogen in Metals was first given in Fall 2002 to provide a general conceptual background for the ongoing research in the Condensed Matter Physics group at the Vrije Universiteit. The present version has benefited from the valuable contribution of Dr. Andreas Züttel, who has been appointed extraordinary professor at the Vrije Universiteit in 2003.

This course is primarily intended for Master and PhD students. It can however also be useful for Post-doctoral fellows that are new in the field. We hope that it will enhance the interest of young researchers for hydrogen in metals and, in a wider perspective, that it will contribute to building up a collaboration platform for the national NWO program “Sustainable Hydrogen”.

Amsterdam, October 22, 2003 Ronald Griessen and Andreas Züttel