

www.quantemolDB.com



## Validated Plasma Chemistries Database

The QDB mission is to  
provide plasma chemistry  
data and solutions to meet  
the ever changing demands  
of industrial and academic  
plasma modelling research

2020 Brochure



## Company Profile

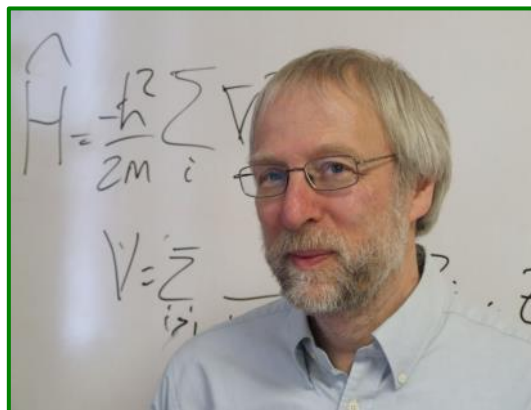
Quantemol was founded by [Prof. Jonathan Tennyson FRS](#) and [Dr. Daniel Brown](#) in 2004. The company develops unique software tools that bring accessibility to highly sophisticated research codes and unique data. Our projects include:

**Quantemol-N Quantemol-EC** use the UK molecular R-matrix code to model electron-polyatomic molecule interactions.

**Quantemol-VT** brings an unsurpassed user experience to the world-renowned plasma simulation codes of Prof. Mark Kushner from the University of Michigan.

**Quantemol-DB (QDB)** is a leading sustainable database, representing the chemical and radiative transport properties of a very wide range of plasmas. The database contains chemistry data for plasma chemistry modelling with pre-assembled and validated chemistry sets, and is regularly updated with the most recent and relevant data.

With an expanding research team, Quantemol is able to offer consultancy projects carried out by world-leading scientists in their respective fields.



Prof. Jonathan Tennyson, FRS, UCL

## Our mission statement is

"To serve our users in industry and academia, to simulate complex processes more efficiently, reliably, accurately and cost-effectively and thereby accelerate technological and scientific innovation."



## Contact Details

Quantemol Ltd  
320 Angel  
City Road  
EC1V 2NZ

+44 208 133 51 03  
[info@quantemol.com](mailto:info@quantemol.com)





## Background

Plasma chemistry has the potential to help address some of the world's most complex issues such as global warming and pollution. It has already enabled technologies which improve our standard of living and environment. Semiconductors, thin-layer manufacturing, plasma medicine, combustion and agriculture are just some of the industries in which plasmas are frequently used.

The purpose of QDB is to provide a forum for collaborative efforts between academia and industrial research, allowing researchers to access, compare and improve their understanding of chemistry sets influencing plasma behaviour.

One of the most challenging aspects of plasma modelling is insufficient chemistry data. Access to a unified and convenient database with complete and validated data sets allows businesses to expand their knowledge of plasma processes and widen their use in industrial applications.

## Why Quantemol?

Quantemol is a market leader in providing unique cross-section data for plasma chemistry software and consultancy services in the field of plasma modelling.

Our advanced methods are employed to perform theoretical calculations and inform estimates for missing chemical reactions.

QDB contains chemistry data for plasma modelling with pre-assembled and validated chemistry sets, applications allowing users to assemble their own sets and run Global model

## What is QDB?

The Quantemol chemistry database includes the following data and services:

- Database search for reactions and species
- Flexible graphs for cross sections data
- Over 40 pre-assembled chemistry sets
- Dynamic Chemistry Generator app to make the reactions list for a new chemistry
- Download up to 20 datasets/month for FREE
- NEW! Boltzmann solver online
- NEW! Global Plasma Model available online
- Request a chemistry set optimisation

## Key advantages of QDB

- All data in one place: electron scattering, heavy particle collisions, surface chemistry – eliminating the need mix and match different sources.
- Use the data with confidence. QDB uses only trustworthy and validated data that is monitored on a regular basis.
- Save time on chemistry set search, comparison, and validation. Easy to use tools will help you to assemble the set you need in minutes.
- Save time with QDB's intuitive interface for exporting data in flexible formats, avoiding human error.
- Don't struggle alone - reach out to our active customer support.
- Collaborate with us. Provide your feedback and request the data you want - we'll do our best to add it for you.

## QDB Testimonial

We use extended duration, cyclical, "life tests" to validate the durability and reliability of a product during its development. Depending on the product and its application, these life tests can be highly resource-intensive which leads to increased cost. When testing involves plasma, it becomes significantly more complicated to scale back resource consumption without changing the characteristics of the plasma and affecting the outcome and relevancy of the test.

The QDB global plasma model tool from Quantemol, coupled with their extensive plasma collisions and reactions database, enabled us to rapidly explore various optimization methodologies and parameters for the plasma-based life test of a new product we're developing. We were able to arrive at an optimized plasma process which gives us equivalent species densities and an electron temperature as close as possible to the intended, final application process. This optimized process uses roughly 30 times less resources than the final application process. The money we saved pays for the subscription to QDB about 100 times over. We are quite satisfied!



**Member of Technical Staff, [Corporation name withheld]**

## QDB beyond just data

QDB includes various types of data which is of interest for plasma modellers.

Data Model:

Species

- Reactions (cross sections/rates)
- Electron, heavy particle, photon
- Thermodynamic (soon)
- Full bibliographic records
- Pre-assembled (and validated) chemistries

QDB includes not only a comprehensive library of reactions data but additional functionalities enabling members to use the data and address their questions about plasmas.

### API feature

The *Application Programming Interface* (API) is a set of protocols and tools for linking the database with our plasma modelling software QVT. An API specifies how software components should interact and APIs are used when chemistries can be accessible in graphical user interface (GUI) of the plasma modelling software.

This will help users to save time and avoid human error when transferring the data to their models and keep chemistry data up to date, whilst the library of chemistry sets will be growing.

### Subscribe to access a growing library of complete chemistry sets:

Ar	N <sub>2</sub> /H <sub>2</sub>	Ar/O <sub>2</sub>	He/O <sub>2</sub>
He	Ar/H <sub>2</sub>	Ar/O <sub>2</sub> /C <sub>4</sub> /F <sub>8</sub>	CF <sub>4</sub> /CHF <sub>3</sub> /H <sub>2</sub> /Cl <sub>2</sub> /O <sub>2</sub> /HBr
H <sub>2</sub>	O <sub>2</sub> /H <sub>2</sub>	SiH <sub>4</sub> /Ar/O <sub>2</sub>	CH <sub>4</sub> /N <sub>2</sub>
N <sub>2</sub>	SF <sub>6</sub> /O <sub>2</sub>	Ar/Cu	SF <sub>6</sub> /CF <sub>4</sub> /O <sub>2</sub>
O <sub>2</sub>	CF <sub>4</sub> /O <sub>2</sub>	Cl <sub>2</sub> /O <sub>2</sub> /Ar	Ar/Cu/He
	SF <sub>6</sub>	Ar/BCl <sub>3</sub> /Cl <sub>2</sub>	Ar/NF <sub>3</sub>
	CF <sub>4</sub>	Ar/NH <sub>3</sub>	SF <sub>6</sub> /CF <sub>4</sub> /N <sub>2</sub> /H <sub>2</sub>
	C <sub>4</sub> F <sub>8</sub>	CH <sub>4</sub> /H <sub>2</sub>	Ar/NF <sub>3</sub> /O <sub>2</sub>
	SiH <sub>4</sub>	C <sub>2</sub> H <sub>2</sub> /H <sub>2</sub>	C <sub>2</sub> F <sub>6</sub> /SiO <sub>2</sub>
	SiH <sub>4</sub> /NH <sub>3</sub>	CH <sub>4</sub> /NH <sub>3</sub>	CF <sub>4</sub> / SiO <sub>2</sub> (s)
		C <sub>2</sub> H <sub>2</sub> /NH <sub>3</sub>	CF <sub>4</sub> /O <sub>2</sub> /N <sub>2</sub> /H <sub>2</sub> (1-30 mTorr)
		CF <sub>4</sub> /O <sub>2</sub> /H <sub>2</sub> /N <sub>2</sub>	O <sub>2</sub> (600 Torr)
			BCl <sub>3</sub> /Cl <sub>2</sub> /Ar (1 - 10 mTorr)

### Surface Processes

Quantemol is developing a data model for representing surfaces and surface processes, and populating the database with relevant data.

QDB now also hosts some data for surface processes split into two categories: Data for plasma simulations such as sticking coefficients and data for surface models (site-base or feature profile).

We currently have sticking coefficients for atomic oxygen, atomic fluorine, fluorocarbons, and silane radicals.

For surface mechanisms such as specific etches, the database provides a set of individual reactions with their associated probabilities.

For energy-dependent reactions, the formula and the value of the used parameters is given.

These sets can be used in site-based or feature profile models.

Etching Mechanisms: Chemical Silicon Etch with Fluorine II

Based on sticking coefficients calculated via molecular dynamics

The values for individual coefficients depend heavily on the exact surface composition. They should be interpreted as guidelines rather than exact values.

Reaction	Formula	Coefficients	Comment
F + Si(s) → SiF(s)	-	0.98	Between 173 K and 300 K
F + SiF(s) → SiF <sub>2</sub> (s)	-	0.93	Between 173 K and 300 K
F + SiF <sub>2</sub> (s) → SiF <sub>3</sub> (s)	-	0.60	Between 173 K and 300 K
F + SiF <sub>3</sub> (s) → SiF <sub>4</sub> + Si(s)	-	0.24	Between 173 K and 300 K

S. Tinck, E. C. Neyts, A. Bogaeerts, 'Fluorine-Silicon Surface Reactions during Cryogenic and Near Room Temperature Etching', *J. Phys. Chem. C* **118**, 30315 (2014). [link to article](#) [B600]

QDB is now featuring download format for **COMSOL, ChemKIN, CFD-ACE+, HPEM, VisGlow** plasma modelling software packages.

If you would like to use assembled chemistry sets including species, reactions and cross-section data in your plasma model, you can easily download data in a compatible format and proceed to modelling right away.

## Data applications

REACTION SELECTION AND DOWNLOAD

BOLTZMANN SOLVER

GLOBAL MODEL

### FEED GASES

- |  |  |
|--|--|
| <input type="checkbox"/> Al                            | <input type="checkbox"/> Ar                            |
| <input type="checkbox"/> BCl <sub>3</sub>              | <input type="checkbox"/> C <sub>2</sub> H <sub>2</sub> |
| <input type="checkbox"/> C <sub>4</sub> F <sub>6</sub> | <input type="checkbox"/> C <sub>4</sub> F <sub>8</sub> |

### Dynamic Chemistry app

This application helps to gather data which is already in QDB related to feedstock gases of the plasma and assemble your own set quickly.

User has flexibility to choose which species and which reactions they want to download and the format they want to download in. Download is only available for Gold and Platinum members.

### Global Model app

After picking the chemistry set users have an option to run a Global Model right there on QDB. It reads QDB data in Arrhenius form fitted to cross-sectional kinetic data. The global model calculates the reactor averaged particle densities and the electron temperature for a given set of process parameters.



Currently the online model assumes constant power for free version and there is an option to include pulsing for Gold membership holders.

Solving equations:

- \* Particle density balance for heavy species
- \* Charge neutrality
- \* Electron energy density balance

The model is a simplified tool to give you some idea about the scale of the species concentrations and dominant species.

A detailed documentation can be found [here](#).

*We have access to more advanced Global Models in-house and can offer consultancy services calculating surface chemistry interactions and other properties.*

### Boltzmann Solver

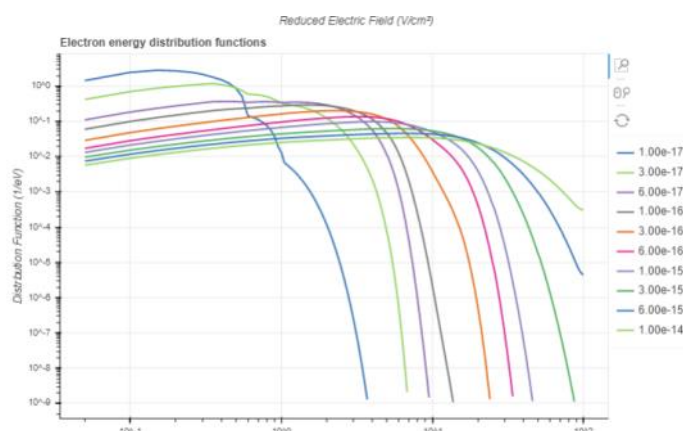


If you are working with non-

Maxwellian distributions and need to obtain suitable reaction rates quickly there is another handy tool on QDB: Boltzmann Solver. It is based on the formalism described in [S. D. Rockwood, "Elastic and Inelastic Cross Sections for Electron-Hg Scattering from Hg Transport Data", \*Physical Review A\* 8, 2348-2358 \(1973\)](#). It was extended to a non-uniform energy grid.

Calculations can be set up for both pre-assembled and self-generated chemistry sets. Only inputs are the relative densities of relevant species and the neutral gas temperature.

As a default, the feed gases are taken into account. For reactive gases or suspected high densities of excited/charged species, additional species from the chemistry set can be added by the user.



The solver calculates EEDFs, effective electron temperature, and rate coefficients for electron collisions in the chemistry set you selected for a gas temperature of choice.

## Industrial advisory board



**Dr. Alok Ranjan**

Manager & Senior Member of Technical Staff

TEL Technology Center, America, LLC, USA.

Area of expertise: Modelling and simulation of plasma etch, plasma etch process development, plasma diagnostics.



**Dr. Shahid Rauf**

Principal Member of Technical Staff and Senior Director

Applied Materials Inc., USA.

Area of expertise: Modelling of plasma processing systems, physics and chemistry of plasma materials processing.



**Dr. Ankur Agarwal**

Director at KLA Corporation, USA.

Area of expertise: Hardware design, manufacturing process development and modelling of plasma processes for various stages of microelectronics device fabrication.



**Dr. Sumeet C. Pandey**

Principal Engineer, *ab initio* Research Lead, Technology Development, Micron Technology Inc.

Area of expertise: Atomistic simulations of plasma-material interactions for deposition and etch, First-principles-based materials and emerging device modelling, DFT-based calculations of surface and gas-phase chemistry and spectroscopy .



**Dr Saravanapriyan Sriraman**

Technical Director,

Lam Research Corporation, USA.

Area of expertise: Product development and engineering, multi-scale modelling and simulation of plasma processing and plasma-material interactions; physics and chemistry of plasma materials processing; plasma diagnostics; plasma etch process development.



**Dr. Sebastian U. Engelmann**

Research Staff Member and Manager, IBM Research.

Area of expertise: Plasma etch process development; plasma-surface interactions, plasma diagnostics.



## Academic Advisory Board



**Annemie Bogaerts**

Professor of Chemistry,  
Research group  
PLASMANT University of  
Antwerp, Belgium.

Area of expertise: Plasma chemistry modelling, plasma reactor modelling, modelling plasma-surface interactions and experiments, mainly for environmental/energy and medical applications.



**Annarita Laricchiuta**

Researcher, PLASMI Lab  
at CNR NANOTEC Bari,  
Italy

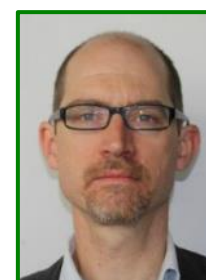
Area of expertise: State-resolved electron-molecule cross-section calculations, molecular structure.



**Bastiaan J Braams**

Physicist, "Centrum  
Wiskunde & Informatica  
(CWI)", the Dutch national  
centre for mathematics  
and computer science, the  
Netherlands.

Area of expertise: Molecular modelling, potential energy surfaces, plasma physics, atomic and molecular data, molecular dynamics for scattering and spectroscopy.



**Christian Hill**

Unit Head, Atomic and  
Molecular Data Unit,  
Nuclear Data Section,  
International Atomic  
Energy Agency (IAEA),  
Vienna, Austria.

Area of expertise: Database design, online interfaces, molecular spectroscopy, atomic and molecular data.



**Christopher Whitehead**

Emeritus Professor of  
Physical Chemistry,  
School of Chemistry, The  
University of Manchester,  
UK.

Area of expertise: Plasma chemistry. Use of atmospheric, non-thermal plasma for the removal and conversion of environmental pollutants and the production of high-value products and fuels from methane and carbon dioxide.



**E. Krishnakumar**

Senior Professor, Natural  
Sciences Faculty, Tata  
Institute of Fundamental  
Research, Mumbai.

Fellow, Indian Academy of  
Sciences, Bangalore.

Area of expertise: Measurement of electron ionization and dissociative attachment cross-sections, dynamics of molecular negative ions, photoionization and photodetachment, electron and ion spectrometry.



**Jean-Paul Booth**

Professor of Physics,  
CNRS Research Director  
at Laboratoire de Physique  
des Plasmas, Ecole  
Polytechnique, Palaiseau,  
France. Fellow of AVS.

Area of expertise: Laser and other optical diagnostics of plasmas in reactive gases. Physics and chemistry of radiofrequency plasmas for surface processing.



**Jonathan Tennyson**

Massey Professor of  
Physics, Fellow of the  
Royal Society,  
Department of Physics  
and Astronomy,  
University College  
London, UK.

Area of expertise: Electron molecule scattering cross-sections calculations, molecular structure and molecular spectroscopy.

## Academic Advisory Board



### Julian Schulze

Associate Professor, Institute for Electrical Engineering, Ruhr-University Bochum, Germany. Research Professor, Department of Physics, West Virginia University, USA.

Area of expertise: Low temperature plasma science, plasma diagnostics and simulations.



### Luis Lemos Alves

Professor of Physics, Instituto Superior Técnico, Universidade de Lisboa, Portugal  
Head of group N-Plasmas Reactive: Modelling and Engineering (N-PRiME) with Instituto de Plasmas e Fusão Nuclear.

Area of expertise: Plasma modelling and simulation, fluid modelling of dc/rf/microwave reactors, kinetic modelling using Chemistry-Boltzmann solvers, data assessment, verification and validation.



### Jung-Sik Yoon

Deputy Director of Plasma Technology Research Center, National Fusion Research Institute, Korea.

Area of expertise: Atomic and molecular data evaluation, generation of plasma processing data set, and data analysis.



### Matthew Goekner

Fellow of the AVS  
Professor of Physics and Associate Dean of Natural Sciences, University of Texas at Dallas Richardson TX, USA.

Areas of expertise: Experimental IR absorption and electron impact excitation cross-section measurements. Experimental and computational plasma physics.



### Khaled Hassouni

Professor of Physics, Director of Le Laboratoire des Sciences des Procédés et des Matériaux (LSPM), CNRS-INSIS, France.

Area of expertise: Plasma diagnostics, low temperature plasma, analytical plasma modelling.



### Miles Turner

Professor of Physics, National Centre for Plasma Science Technology, Dublin City University, Dublin, Ireland.

Area of expertise: Plasma theory and simulation, plasma chemistry modelling, verification and validation.



### Klaus Bartschat

Levitt Professor of Physics, Fellow of the American Physical Society, Department of Physics and Astronomy, Drake University, Des Moines, Iowa, USA

Area of expertise: Electron and photon collisions with atoms and ions.



### Nigel Mason

Professor of Physics, Department of Physical Sciences, The Open University, UK .

Area of expertise: Experimental electron molecule scattering cross-sections and molecular spectroscopy.



## Academic Advisory Board



### Peter Bruggeman

Professor of Mechanical Engineering and Associate Department Head, University of Minnesota, Minneapolis, MN, USA  
Director High Temperature and Plasma Laboratory.

Area of expertise: Plasma diagnostics, non-equilibrium plasma physics and chemistry, plasma technologies for environmental, chemical, energy, biomedical and decontamination application, plasma-surface interactions, multiphase plasmas in and in contact with liquids.



### Uwe Czarnetzki

Professor of Physics, Ruhr-Universität Bochum, Institute for Plasma und Atomic Physics, Germany.

Area of expertise: Basic plasma physics, plasma sources, plasma diagnostics, spectroscopy, non-linear optics, atomic / molecular physics.



### Satoshi Hamaguchi

Professor of Physics, Center for Atomic and Molecular Technologies, School/Graduate School of Engineering Osaka University, Japan.

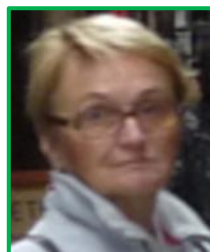
Area of expertise: theoretical and computational plasma physics, strongly coupled plasmas, plasma processing.



### Yi-Kang Pu

Professor of Physics Department of Engineering Physics, Tsinghua University, Beijing, China.

Area of expertise: diagnostics for low temperature plasmas, discharge physics, plasma instabilities, plasma source development.



### Tatyana Rakhimova

Leading scientist, Head of theoretical Group, Microelectronics Department, Skobeltsyn Institute of Nuclear Physics at Moscow State University, Russia

Area of expertise: Physical processes in gas discharges, plasma chemistry and plasma-surface interaction.



### Yuki Itikawa

Professor Emeritus, Institute of Space and Astronautical Science, Sagami-hara, Japan.

Area of expertise: Theoretical studies of electron collisions with atoms and molecules and photoionization of atoms and molecules. Compilation and evaluation of atomic and molecular data.



### Timo Gans

Professor of Low Temperature Plasmas, Head of Research in the Department of Physics, University of York, UK.

Areas of expertise: Plasma science and technology, advanced optical diagnostics, computational modelling, plasma dynamics, chemical kinetics.



### Zoran Lj. Petrović

Professor of Physics, Fellow of the Serbian Academy of Sciences and Arts and of American Physical Society, Institute of Physics, University of Belgrade, Serbia.

Area of expertise: Electron molecule scattering, swarms and transport of electrons, positrons and ions, physics of ionized gases, gas discharges, plasma diagnostics and modeling, plasma applications including plasma medicine.

## Price List\*

Membership	User	Annually*	3 years*
Standard	Academic/ Industrial	FREE	FREE
Gold	Academic	£2,000	£4,500
Gold	Industrial	£5,280	£13,200
Platinum	Academic	£5,000	N/A
Platinum	Industrial	£15,000	N/A

\* - all prices are quoted excluding VAT

**Additional IDs** - additional users in the same organisation will be offered a discounted price.

**Industrial research** - research by commercial organisations or for commercial organisations where results that are not made publicly available.

**Academic research** - research by not-for-profit organisations producing publishable results.

Standard	Gold	Platinum
<ul style="list-style-type: none"> <li>Database search for reactions and species</li> <li>Flexible graphs for cross sections data</li> <li>Use Dynamic Chemistry Generator app to make the reactions list for a new chemistry</li> <li>NEW! Download up to 20 datasets/month</li> </ul>	<ul style="list-style-type: none"> <li>Database search for reactions and species</li> <li>Access to over 40 pre-assembled chemistry sets</li> <li>Use Dynamic Chemistry Generator app to make the reactions list for a new chemistry and download it in a flexible format</li> <li>NEW! Download UNLIMITED datasets/month</li> <li>NEW! Download up to 20 Chemistry sets/month</li> <li>NEW! Download up to 20 Dynamic Chemistry sets/ month</li> <li>Flexible graphs for cross sections data</li> <li>Download data in flexible software formats: COMSOL, Chemkin, Vls glow, CFD ACE +, QVT</li> <li>Customer support on working with chemistry data</li> </ul>	<ul style="list-style-type: none"> <li>All benefits of the <b>Gold</b> membership</li> <li>Calculations of cross sections* for up to six molecules/ions within the membership one-year term.</li> <li>Cross sections included* in the deal are here:               <ul style="list-style-type: none"> <li>Electronic excitation cross-sections</li> <li>Quenching cross-sections</li> <li>Electron impact dissociation</li> <li>Estimate dissociative electron attachment</li> <li>Electron impact ionisation at all energies</li> <li>Estimate branching ratio for electron impact ionisation and dissociation</li> <li>Vibrational cross sections for diatomic molecules (N<sub>2</sub>, FO, CF etc)</li> </ul> </li> <li>A comprehensive report about the calculations and data in any format you require</li> </ul>

\* - Calculations choice will be at the discretion of Quantemol, i.e. if there are specific cases where no reasonable calculations are possible the member will be informed and justification provided. We will make our best efforts to deliver for all of the requests.

### Quantemol Database Terms policy

The details on general terms of use and privacy policy can be found here:

[www.QuantemolDB.com/about/legal/](http://www.QuantemolDB.com/about/legal/)

## CONSULTANCY

As well as providing advanced modelling software, Quantemol provides a unique consultancy service. With our suite of software and highly skilled engineers, we provide extensive and in depth analysis tailored to specific customer requirements. Consultancy projects range from small quick calculations work to comprehensive plasma chemistry development. Typical types of consultancy work provided are:

- Calculation of specific electron-molecule cross-sections including:
  - ⇒ Electron impact dissociation cross-sections producing specific products
  - ⇒ Electron impact ionisation dissociation producing specific products
- Heavy particle collision cross-section calculations for neutral particles colliding
- Vibrational excitation cross-section calculation for diatomic molecules and ions
- Industrial plasma tool simulations
- Plasma process parameter optimisations
- Plasma chemistry designs
- Plasma etching and deposition calculations
- General multiphysics problems (CFD, etc)



Quantemol has successfully undertaken several large consulting projects. A distinctive feature of our service is that we work with non-standard requests, using computational methods and literature research in order to achieve results to strict deadlines. We always strive to deliver results of value to our customers and prioritise research tasks according to our client's development needs. A formal completion report is produced at the end of all work providing the results (raw data, graphs, videos etc) ready for use and presentation. We work on the basis of complete confidentiality and understand the importance of protecting intellectual property.

