# Aluminium Etching

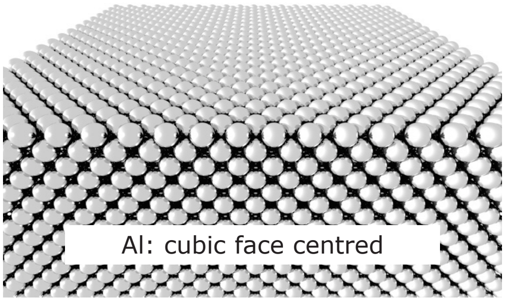
**Revised: 2013-11-07** **Source:**
www.microchemicals.com/downloads/application_notes.html

## Concentrations

All chemicals concentrations mentioned in this chapter with a * refer to a conventional concentration listed in the last section of this document.

## Aluminium

Aluminium has a density of 2.7 g/cm$^3$ and therefore belongs to the light metals. Its crystal structure is cubic face centred.




Due to its high electric conductivity, aluminium is used for conductors in microelectronics where it is often alloyed with copper in order to prevent electro migration, or with silicon in order to prevent the formation of (silicon-consuming) aluminium-silicon alloys.

With a standard potential of -1.66 V, aluminium does not belong to the noble metals. However, the formation of a very thin (few nm) $Al_2O_3$ film makes it very inert in many substances. Therefore, Al etchants require at least compounds for dissolving $Al_2O_3$ as well as for etching (or, respectively, oxidizing) aluminium.

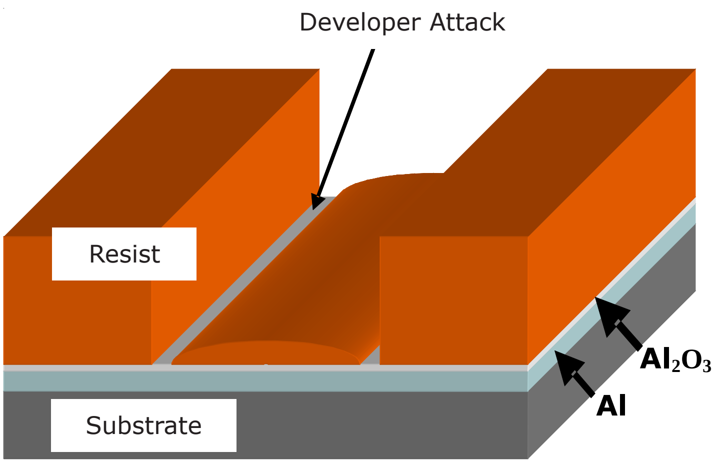
## Aluminium Etching Mechanism

Typical Aluminium etchants contain mixtures of 1-5 % $HNO_3$* (for Al oxidation), 65-75 % $H_3PO_4$* (to dissolve the $Al_2O_3$), 5-10 % $CH_3COOH$* (for wetting and buffering) and $H_2O$ dilution to define the etch rate at given temperature.

Aluminium etching is highly exothermic, an (inevitable, since isotropic etching) underetching of the resist mask causes local heating (increased etch rate) and super-proportional underetching of the mask as a consequence, if no agitation is performed.

Strong $H_2$-bubbling reduces etch homogeneity. Improvements of the etch rate homogeneity can be achieved if the etching will be interrupted every approx. 30 seconds by a short dip into DI water. hereby, the $H_2$ bubbles temporarily vanish.

Generally, etching starts after the dissolution (by $H_3PO_4$) of few nm $Al_2O_3$ film present on every Al surface. For this reason, the photoresist processing impacts on the Al etching: The alkaline developers preferentially dissolve the $Al_2O_3$ where the resist is primarily through-developed (at regions with lower resist film thickness, near the edges of cleared structures, or below cleared structures with larger features).



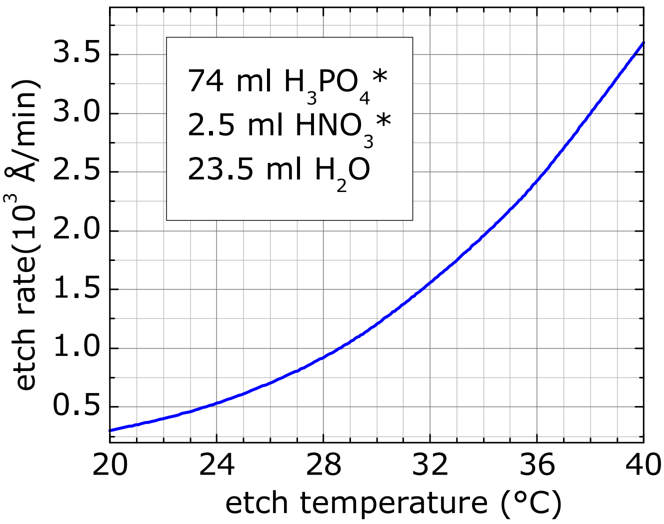

Dependant on the extent of (desired or undesired) over-developing as well as delay between development and Al-etching, the process parameters may lead to a spatial inhomogeneous Al etching start.

## Etch Rate and Selectivity

The Al etch rate of $H_3PO_4/HNO_3$ mixtures strongly depends on the temperature (fig. right-hand for a certain composition, after the removal of the $Al_2O_3$-layer on the Al surface) and doubles approx. all 5 °C.

Aluminium alloyed with few % of Silicon shows a comparable etch rate as compared to pure Aluminium.

Most Al etchants attack copper significantly more then aluminium. The nickel etch rate is lower then the aluminium etch rate. Titanium, chromium and silver are hardly etched, noble metals such as gold or platinum are not attacked.




## Our Aluminium Etch

Our aluminium etchant ANPE 80/5/5/10 has the following composition:

$H_3PO_4$ : $HNO_3$ : $CH_3COOH$ : $H_2O$ = 73 %: 3.1 % : 3.3 % : 20.6 %

We supply this mixture in 2.5 L sales volumes in VLSI quality. Other grades/sales volumes available on request.

## Suited Photoresists and their Processing for Al Etching

All AZ® and TI resists are suited and sufficiently stable as mask for etching few µm of Aluminium. Generally, we recommend the usage of resists with optimized adhesion such as the AZ® 1500 series (resist film thickness range approx. 0.5-3 µm via the AZ® 1505, 1512 HS, 1514 H, and 1518), or the AZ® 4533 (3-5 µm).

The deeper Al has to be etched, the ticker the resist film should be. If this requires a high aspect ratio, we recommend the high-resolution AZ® ECI 3000 series (resist film thickness range approx. 0.5-4 µm).

Since most NaOH-, KOH-, or TMAH-based developers attack Aluminium at a rate of approx. 50-100 nm/min, sensitive processes require an Al-compatible developer such as the „AZ® Developer" with very low Al attack.

In order to improve the resist adhesion, a hardbake after development can be beneficial. We recommend 140-145°C for 5-10 minutes. Since the resist film hereby embrittles, the cooling down to room temperature should not take place abruptly in order to prevent the formation of cracks.

For resist removal after etching, the „AZ® 100 Remover" can be used as long as no dilution or contamination with water (even in traces!) occurs, otherwise Al will strongly be attacked. In case of sensitive processes, the pH-neutral organic solvents NMP or DMSO are more suited.

All resists and ancillaries mentioned in this section are distributed by us and more detailed in the document Photoresists, Developers, and Removers.

## Dilution Grade of the Substances Mentioned in this Document

$HCl$* = 37% $HCl$ in $H_2O$

$H_2SO_4$* = 98% $H_2SO_4$ in $H_2O$

$H_2O_2$* = 30% $H_2O_2$ in $H_2O$

$NH_4OH$* = 29% $NH_3$ in $H_2O$

$HNO_3$* = 70% $HNO_3$ in $H_2O$

$HF$* = 49% $HF$ in $H_2O$

$H_3PO_4$* = 85% $H_3PO_4$ in $H_2O$

$CH_3COOH$* = 99% $CH_3COOH$ in $H_2O$

## Disclaimer of Warranty

All information, process guides, recipes etc. given in this brochure have been added to the best of our knowledge. However, we cannot issue any guarantee concerning the accuracy of the information.

We assume no liability for any hazard for staff and equipment which might stem from the information given in this brochure.

Generally speaking, it is in the responsibility of every staff member to inform herself/himself about the processes to be performed in the appropriate (technical) literature, in order to minimize any risk to man or machine.