Why Photo Mask Cleaning? (LED Production)

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Abstract*: It can say that explosive expansion of LED manufacturing had been planned like a boom and many factories been built in the year of 2011 in China. Majority of new lines have already been in its production and others are still under stating up. But anyhow, sooner or later, LED manufacturers will compete its rate of yield as well as Productivity. Then, it is time for Mask cleaning. This paper introduce how and why Mask cleaning are necessary in due course of grownup of its LED production.*

Key words*: Resist Removal, Alkaline based Cleaning Chemical, Cleaning quality and throughput Recipe selection, variety of Chemical use, Cost reduction*

INTRODUCTION

Production expansion on LED chips increase UV radiation on Photolithography process as well. Most LED production lines become 24/7 operations, and so UV exposure process by Aligner. A lot of photo masks are required in timely manner to meet such operation. Manual Mask cleaning may face its quality issue and its efficiency. Technically, removing Resist residue is most troublesome process.

1. Typical Mask Cleaning Process

Mask cleaning process is categorized to 5 steps shown in Figure-1 (Ultra Sonic cleaning is an option). Those steps are:

Step-1) Resist Removal: Dip-in the Mask to Chemical pot, then.

Step-2) Rinse by DIWater (Deionizer Water): To remove Chemical element from the Mask.

Step-3) Particle removal; surfactant chemical is spray while brush is rotated to scrub the Mask,

Step-4) Rinse by DI Water: DI Water is sprayed to rinse chemical element.

Step-5) Dry by Hot DI Water: Drying by pulling up the mask from the Hot DI Water.

If Ultra-Sonic cleaning were facilitated, this would apply at the Step-1 chemical pot. See Chart-1 as sample cleaning process with standard recipe. And See Picture-1 as Cleaner for LED use.

As mentioned in Introduction, Resist Removal is the most difficult step of Mask cleaning, because choosing Chemical is not easy, finding out a best USE of chemical is also not easy. When focus on choosing Chemicals, many group of Chemicals are on the Table-1

Chart-1

Cleaning Process Chart (Standard Sample Recipe)

Sample Recipe

工程 **Process**	Time Chart	Duration (Seconds)*1	Chemical & Utilities /Recommendable*2
Removal of Resist by Chemical dip Pot		60	1)TRC-1310 (100%) or 2)TRC-170(30%)
Ultrasonic Cleaning		*5 (including 60S of US)	(xx%) is chemical concentration
RINSE-1		60	DI Water
Scrub Cleaning with Surfactant		60	3)TRC-123 (5%) or 4)TRC-151(10%)
RINSE-2		60	DI Water *3
DRY by Hot DIW		60	DIWater
	Total :	**300**	Sec.
		5	Min.

Note:

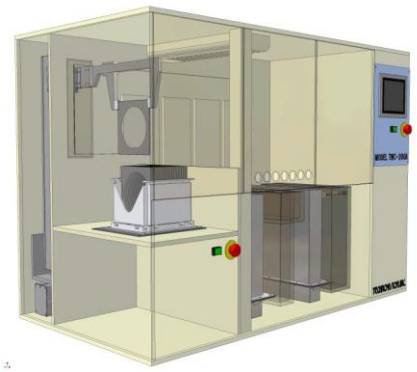
*1: Duration is reference only

*2: Chemicals 1)TRC-1310 is for Removal of resist residue (Strong Peel/ Inorganic Alkaline)
2)TRC-170 is for Removal of resist residue (Cleaning / Organic Alkaline)
3)TRC-123 is for soft scrub cleaner (Surfactant / Inorganic Alkaline)
4)TRC-151 is for soft scrub cleaner (Surfactant / Neutral)

*3 : DI Water (De ionized Water)

*4 : DRY by Hot DIwater : Drying by Pulling up the Mask from hot DIWater

*5 : Activiate Ultrasonic cleaning for 60S. At the last period of Chemical Dip. Process. (Option)



Picture-1

Mask cleaner for LED Production

2. Current situation on what cleaning chemicals are used and their problems

According to our study in Mask cleaning fields, most frequently used Chemical is:

(a) Organic solvent such as (ACETONE, ETHANOL and IPA) in Fume Hood. These are common chemical for easy obtaining and less expensive. Problems: Flammable and hazardous in handling at fume Hood

(b) Resist chemical family such as (DEVELOPER-TMAH based chemical, and STRIPPER). These are effective under some conditions, but what happen if copied resist to the Mask is undertaken 100-time of UV radiation. They should have become very hard to remove. Thus, Cleaning performance is sometime GOOD and sometimes NOT.

Problems: Not stable performance. And handling such chemicals at Fume Hood is not recommendable in viewpoint of human health safety.

(c) RCA Cleaning method is one of most powerful Resist Removal, and, this technology has been well proven in every aspect since RCA disclosed the idea on 1965. Problems: Cleaning equipments are huge and expensive. handling in Fume Hood is NG. Cleaning Chemical performance is summarized in Comparison Table-1

Table-1 Comparison Table for Mask Cleaning performance

〈To Remove Resist Contamination〉

	Organic solvent		Alkaline Cleaner by Technovision		RCA Method	Developer/Remover	
Mask condition	Acetone	Ethanol	TRC-1310	TRC-170	SC1(APM)+SC2(HPM)	TMAH	Stripper
Mask with proximity Exposure	○	△	◎	◎	◎	○	◎
Mask with contact exposure	○	×/△	◎	◎	◎	△	◎
Mask with more than 100 times exposures	△	×	◎	○	◎	×/△	○
Mask with after two month of exposure	×	×	◎	○	◎	×	○/△

◎	Ecellent performance
○	Good
△	sometime Good.
×	No hope

3.Evaluation of Alkaline-ethanolamine based Chemical for Resist Removal

We have cooperated with PARKER CORPORATION, Tokyo Japan a Chemical Company, since 2009 about this research and development project to find-out most suitable chemical. Our works on testing and evaluating Customers Masks have been more than 50 samples, and we have reached to the conclusion that Alkaline-ethanolamine based chemical family is a solution. Developed Chemical table for Resist Removal are shown

in Table-2. Our sample Mask cleaning evaluation Data (Photos) are shown as BEFORE and AFTER photos as Figure 2, 3 and 4 respectively. Our targets of each Mask evaluation are explained in topics descriptions of each photo. As the conclusion of evaluation, we have successfully removed all resist copied over the Mask surface with the Alkaline-ethanolamine Chemical. (See Picure-2)

Table−2 CHEMICAL USE Table

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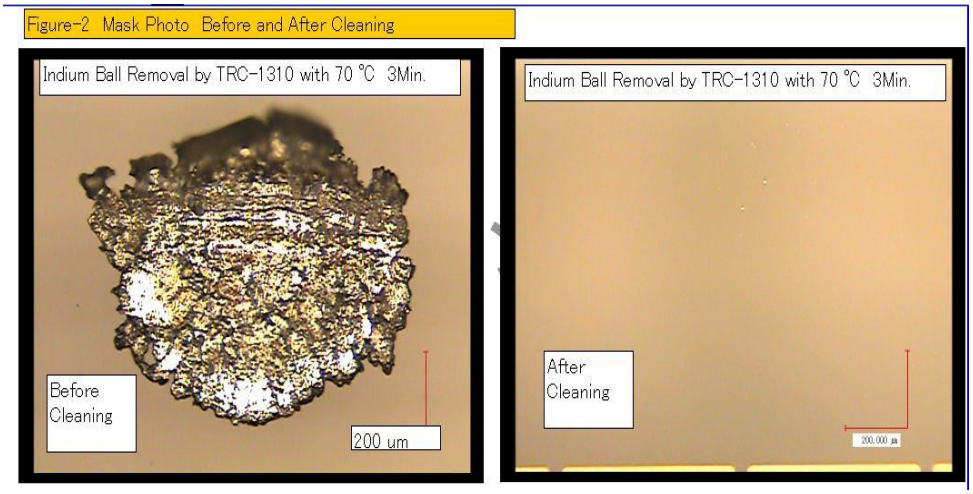
		Chemical Remover	Chemical Cleaner	Scrub Cleaner	Scrub Cleaner
		(For Resist)	(For Resist)	(For Particles)	(For Particles)
		TRC−1310	TRC−170	TRC−123	TRC−151
Specifications	PH(1%)	12.5	12	12.5	Neutral
		Inorganic Alkaline	Organic Alkaline	Inorganic Alkali	Neutral
				Surfactant	Surfactant
Uses	Dilution	As formlated (0 %)	10～30%	1～5%	5% (Normal Use)
					10～50%(Powerful Use)
	Temp.	50～70℃	RT～50℃	RT～40℃	RT～50℃
Regulations	Flammable	N/A	N/A	N/A	N/A
	GHS				N/A
	PRTR	Applicable	N/A	N/A	N/A

OEM Chemical Packaged (Sample TRC-1310)

Picture-2

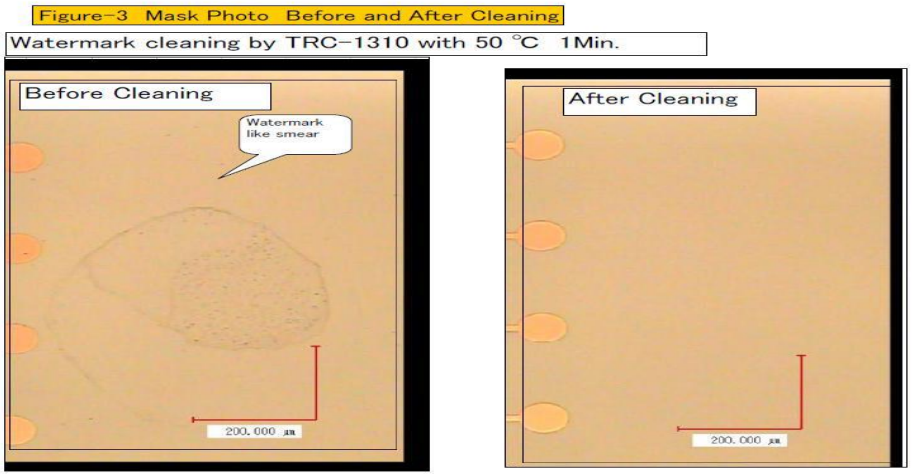
Chemical for Resist Removal with 20kg Tank for LED Production



Figures -2

Before and After Photos

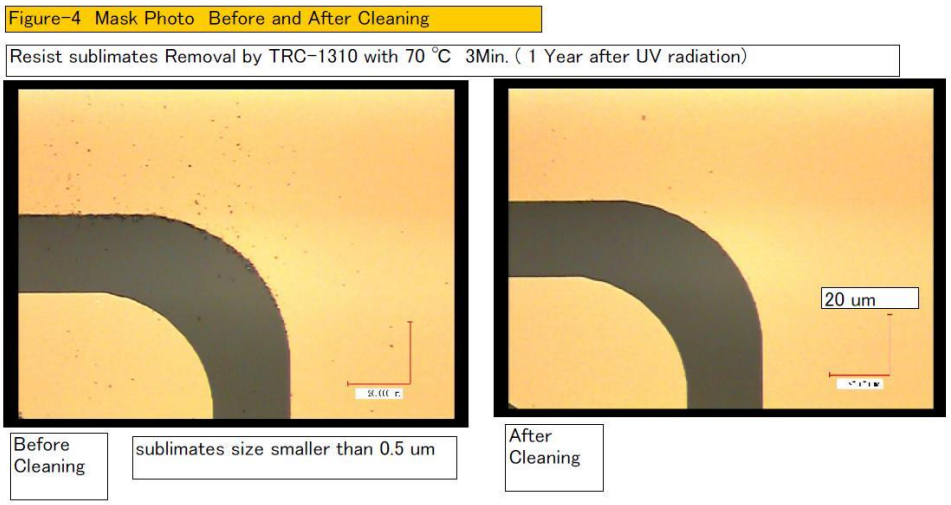
Indium



Figures-3

Before and After Photos

Stain Watermark



Figures-4

Before and After Photos

Sublimated resist

Chart-2

Cleaning Process Chart (One Chemical Use Recipe) Sample Recipe

工程 **Process**	Time Chart	Duration (Seconds)*1	Chemical & Utilities /Recommendable*2
Removal of Resist by Chemical dip Pot		0	1)TRC-1310 (100%) or 2)TRC-170(30%)
Ultrasonic Cleaning		*5 (including 60S of US)	(xx%) is chemical concentration
RINSE-1		0	DI Water
Scrub Cleaning with Surfactant		60	3)TRC-123 10%) or 4)TRC-151(50%)
RINSE-2		60	DI Water *3
DRY by Hot DIW		60	DIWater
	Total :	**180**	Sec.
		3	Min.

Note:

*1: Duration is reference only

*2: Chemicals 1)TRC-1310 is for Removal of resist residue (Strong Peel/ Inorganic Alkaline)
2)TRC-170 is for Removal of resist residue (Cleaning / Organic Alkaline)
3)TRC-123 is for soft scrub cleaner (Surfactant / Inorganic Alkaline)
4)TRC-151 is for soft scrub cleaner (Surfactant / Neutral)

*3 : DI Water (De ionized Water)

*4 : DRY by Hot DIwater : Drying by Pulling up the Mask from hot DIWater

*5 : Activiate Ultrasonic cleaning for 60S. At the last period of Chemical Dip. Process. (Option)

Picture-3)
Photo of Mask Cleaner

Machine is used for
One chemical Recipe
(Shown at Chart-2)
Evaluation
At Technovision Inc.,

4. Recipe of Mask Cleaning

4-1. Current situation and problems: (Other than Resist Removal issue)

1) Most of Mask cleaners are of particle removal and final cleaning by surfactant detergent model, so Resist Removal is not considered --- Quality issue

2) Most mask cleaners are of manual operation type, which requires Manpower--- Cost issue

3) Most masks cleaner facilitated with organic solvent chemical model so, Human safety measure and non-explosive structure is required. --- Safety and Cost issue

4) Inspection after Mask cleaning is not carried out, because of no tool --- Quality issue

5) Throughput becomes a key as production increase. --- Optimize process Recipe

4-2. Identification of issues and **proposed solutions**:

1) Resist removal need Chemical treatment; therefore, we propose Alkaline Chemical dip-in process and not to use Organic solvent. (Solution 3))

2) To lower the cost of Manual operation, a fully automated model is proposed, with 20 Mask/Cassette. Called Cassette-to-Cassette Model Mask cleaner.

3) Avoid using Organic solvent chemical,

4) To inspect quality of after Mask cleaning, we propose a simple GO/NOGO Mask Checker

5) To meet production increase, we evaluate the process, such as selection of Chemical, and its USE as the best Recipe to shorten the process time. See Chart-2 as one solution of to shorten process time by 40_% with a concept of One Chemical Solution.

Conclusions

We, Technovison Inc., and PARKER CORPORATION are a team for Mask cleaning engineering technology which covers from Cleaning Chemical, Cleaning equipment and its software such as making Recipe, as well as supply of Chemical. Therefore, the above-proposed solutions are ready to apply for actual production line.

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REFERENCES