Ceramic Heatsink without Aluminium Fins: N-9H Innovative Ceramic Heatsink

A heatsink plays a significant role in an electric machine because excess heat causes unpredictable troubles and an efficiency drop. The cooling performance of a heatsink is directly linked to the performance improvement of an electric machine. Not only excess heat from machine electric parts, but also small sizing of every machine parts has been required since downsizing of the end products and design liberalization were required.

Fig. 1
Ceramic heatsink and LED components

Nishimura Porcelain was founded and grown up in Kyoto/JP. The company is providing ceramic products since 98 years. Nishimura Porcelain recommends high-performance ceramic heatsinks all over the world. Nishimura Porcelain developed and produces high thermal emittance ceramics, which is named N-9H. N-9H has been in mass production lately as LED heatsinks, which are used for huge outdoor lightings such as tower structure lighting, stadium lighting, and street lamps are required. They are used not only as huge lighting heatsinks, but also as small LED light heatsinks or high-power semiconductor modules, heat sensors, and so on. The material is suitable for any place where heat is generated independently from the available space size.

Keywords
alumina, heatsink

Thermal countermeasure is the key point for LED

LED light has become a major lighting device instead of fluorescent light or incandescent bulb since the LED performance improved. It has the best performance with regard to power consumption and luminous efficiency.

On the other hand, LED engineers always get a setting problem of heat radiating mechanism due to the heat emission intensity from LED lighting, which leads to a product lifetime decreasing. Based on these facts, high heat radiation parts are required for developing high-emission LEDs. A unit which consists of a high thermal conductivity metal plate combined with a cooling fin is the major state-of-the-art method. However, these units take so much space of the LED light units. Also, cooling performance is not enough for a huge usage LEDs.

The three types of heat transfer systems

A unique point of Nishimura's ceramic heatsink material is that it is transferring heat by heat radiation – a method, which is not often used in a heatsink. There are three types of heat transferring systems – heat conduction, heat convection, and heat radiation. The current popular heatsink, which is a metal plate with cooling fins is using heat conduction and heat convection;

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Fig. 2
LED light mount on an N-9H heatsink

Fig. 3
N-9H is used for a LED stand desk light

as the fins have to be in touch with gas or fluid as much as possible, whereas the Nishimura's ceramic heatsink is using the heat radiation method. Therefore a thinner flat plate shape is suitable for the heatsink. This shape is favourable for thin mounted devices and is also suitable for closed ones. The emissivity of N-9H is with 0,97 approximately eight times better than the heat radiation of copper (Tab. 1). The emissivity value 0,97 is one of the best results of alumina ceramics since in general its emissivity is in a range of 0,4 – 0,5. Not only the heat radiation, but also its thermal conductivity is better than standard alumina materials as it is almost two times higher.

Tab. 1
Emissivity and thermal conductivity of various materials

	N-9H	AlN	Cu	Al
Emissivity (100 °C)	0,97	0,93	<0,1	<0,05
Thermal conductivity [W/m · K] (25 °C)	39	180	394	238

Tab. 2
N-9H alumina qualities

Material	**Aluminia**	
Nishimura No.	N-9H	N-9HI (High Thermal C)
Colour	Milky yellow	White
Bulk specific gravity	3,93	3,98
Radiation hate (peak)	0,97	0,98
Thermal conductivity [W/m · K]	39	41
Thermal expansion coefficient [× 10^{-6}/°C]	7,7	
Thermal shock resistivity [°C]	200	
Max. using temperature [°C]	1500	
Bending strength [MPa]	340	450
Young rate [GPa]	340	350
Poisson's rate	0,23	
Dielectric strength [kV/mm]	>15	
Volume resistivity [Ω · cm]	$>10^{16}$	

Why does N-9H have high heat radiation and thermal conductivity?

Nishimura Porcelain's strong point is the material improvement by R & D. The biggest factor of this result is the crystal size. The crystal size of N-9H is around the single digit micrometer range, which is one digit smaller than in general alumina ceramics. Also, the space between the crystals is very small and less than in other materials. If there is an impurity in this space, thermal conductivity will decrease. Therefore the key point for good thermal control are narrow crystal spaces.

Conclusion

Nishimura Porcelain is researching and developing materials all the time. The material N-9H is one fruitful example of the long-term efforts. Almost 20 years ago, Nishimura produced a ceramic heater for a household oven, and this was the base of the idea for the heat radiation ceramic. At that time, quartz was the major covering material of a NiCr-wires heater, but when changing the cover with ceramic radiating infrared-rays, the result for Nishimura was great as the ceramic covers radiation energy more powerful than quartz. On the other hand, the surface temperature of the ceramic cover was 250 °C cooler than the quartz cover with a surface temperature of 800 °C. Based on this results researcher realized that ceramic is also useful for cooling of heating elements.

Nishimura supplies not only N-9H, but also transparent alumina, light-reflecting ceramics, porous alumina, zirconia, coloured ceramics, and more.