Metal Mirror Marvel From Aranmula, Kerala: A Rare Specular Delta Bronze Craft

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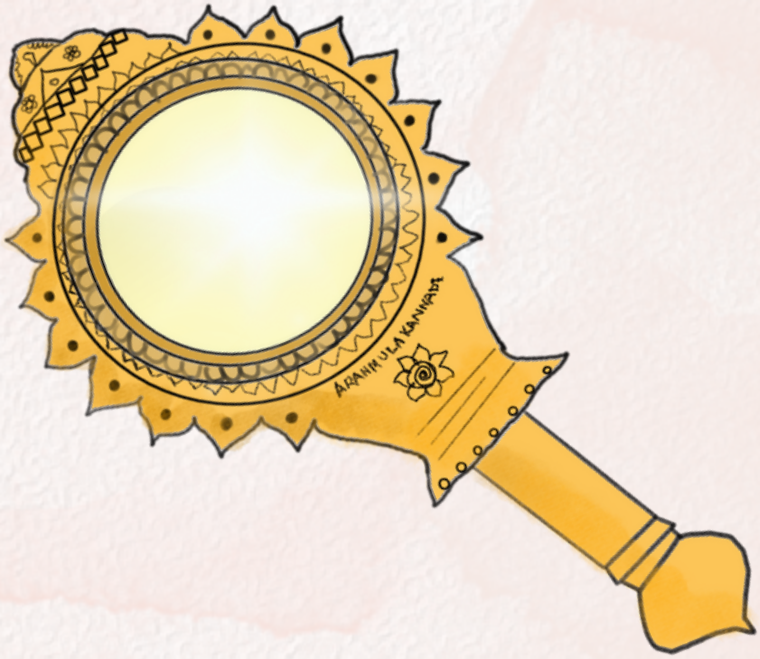

Mirrors are usually synonymous with glass in modern times. Metal mirrors are rare to find in the contemporary age. Yet, Aranmula is a place in Kerala, south of India which is famous for making metal mirrors from the alloy of copper and tin. It is a traditional art practiced by local communities of that village where the entire mirror is handmade. The best part is that the metal mirror is highly polished and carved out in such a manner that it gives an absolute point image with the highest quality of reflectance. This chapter takes its readers to a journey to unveil the history of Aranmula mirrors, its specifications, method of casting, and most importantly the science behind all these spectra to popularise this dying traditional craft of India.

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Mirrors have long held a fascination in antiquity with fine examples going back to the Old World and ancient Egypt. Decorated bronze mirrors have been amongst the most prolific of Chinese objects d'art, some known as 'magic mirrors'. Some of the earliest copper-base mirrors are found from the Indian subcontinent such as at the Harappan site of Dholavira (c 2500 BCE). The *Darpanika* or maiden elegantly gazing into a mirror is a frequent theme in Indian sculptural art over the ages. Although metal mirror making practices seem to have died out elsewhere in the world, a remarkable crafts survival, which was zealously guarded by hereditary families, is still prevalent in Kerala in Southern India. The verdant village of Aranmula is home to an exotic traditional craft of making handcrafted, handheld metal mirrors known as *Val Kannadi*.

Aranmula located by the meandering Pampa river, is best known for the spectacular snake boat races which are held at the time of Onam, the most prominent Malayali religious festival. Here, a unique mirror making tradition has thrived for centuries which was one of the items associated with wedding rituals. The wedding trousseau of brides of the Nambuthri Brahmins and the Nairs, the matrilineal warrior clan, traditionally included the *ashtamangalyam* of eight auspicious articles.

The reflective properties of the Aranmula Kannadi mirror (Fig. 1) are astonishing and in some ways even better than modern day glass mirrors. Modern glass mirrors consist of a thin sheet of glass over a reflective mercury layer. These do not give a point image due to the refraction through glass. On the other hand, if one were to place the point of a pen against the Aranmula mirror, it would give a perfect point image; not to mention with brilliant true colours due to high reflectance across the spectrum!

Figure 1: AranmulaKannadi, or metal mirror made traditionally at Aranmula, Kerala showing brilliant specular reflectance

How was such a highly specular polish achieved using traditional artefacts and simple handcraft alone? The author as part of her archaeometallurgical researches had first visited Aranmula in 1990 to explore the mirror making craft and subsequently has written research papers from studies on samples collected from the workshops such as of late Gopalakrishna Achary and late Janardhan Achary (Srinivasan and Glover 1995, Srinivasan and Glover 2007, Srinivasan 2008). These metallographic studies confirmed that the highly reflective properties of the mirror owed themselves to the skilful casting, optimisation and polishing of a specific highly specular bronze alloy composition.

It was found by the author that the Aranmula metal mirrors were ingeniously made of a binary

copper-tin alloy (of 32-33% tin alloyed to copper), optimising the presence of the delta intermetallic compound phase of bronze of 32.6% tin which forms predominantly within this narrow composition range (Table 1).This silvery-white phase is responsible for the mirror effect due to its high reflectivity across the spectrum. It also makes for a better metal for a mirror than silver, which though it has high reflectance across the spectrum, is very soft and dents easily giving a distorted image. The delta bronze alloy on the other hand is very hard, even harder than steel as found by the author (Vickers hardness of 500 VPN as against steel of 400 VPN), and hence it can take a high polish without distortion giving a good mirror image.

Table 1. Analyses of Aranmula metal mirror specimens using electron probe microanalysis (EPMA-WDS at Institute of Archaeology, London) showing that they consist predominantly of delta high-tin bronze, ie copper alloy with 32-33% tin, and with analysis of phases and hardness measurements.

Object	Cu %	Sn %	Total%	Hardness (VPN)	Analysis of higher tin phases	Analysis of lower tin phase
Polished mirror blank, Aranmula, Kerala, bought in 1991 from Gopalakrishnan Achari	64.73	32.47	97.20	480 VPN	32-34% Sn Predominant matrix of whitish delta (d) phase	26-27% Sn Bluish alpha plus delta (a+d) eutectoid phase
Mirror alloy, Malakkara, Kerala (obtained from Janardhan Achari in 1992 by I. Glover)	66.91	33.39	100.29	500 VPN	32-34% Sn Predominant matrix of whitish delta (d) intermetallic compound phase (32.6% Sn)	28% Sn Bluish alpha plus delta (a+d) eutectoid phase

However, the as-cast alloy of delta bronze (as the author has described this alloy of 32-33% tin-bronze), is very breakable. This brittleness is overcome in clever ways. For one, a very thin blank was cast, of no more than a couple of millimetres, in a specially devised closed-crucible-cum mould. This is achieved by first making a two-piece mould of two clay discs; finely ground with a slip applied to get the smoothest finish. These are separated with fine spacers of the same alloy and then covered with clay such that a neck with a hollow cup is shaped. The alloy to be cast is placed in the cup and the entire crucible-cum-mould is sealed with clay. It is then heated in a hearth with the crucible-cup facing downwards (Fig. 2).

Figure 2: Traditional workshop for casting Aranmula metal mirror

Once the metal in the cup melts, it is tipped over so that it flows into the gap left for the mirror blank. Thermal camera investigations showed a significant differential in temperature between the heated cup and the mould for the blank, which along with the thinness of the blank would have resulted in more rapid cooling to give a homogenous blank and thus reducing the brittleness. The as-cast blank is then retrieved by breaking open the crucible-cum-mould. The silvery oval blank is then pressed onto a wooden mount with heated resin and then polished over several days to get the brilliant reflective surface.

Interestingly, when one looks at sculptural depictions from Indian antiquity such as the 13th century Hoysala sculpture of the *madanika* (or maiden forming the strut), the mirror she holds could well represent such a mirror blank set in a wooden polishing mount. These days, however, the blank is mounted within a brass handle with a tang to be held in the hand.

Of the local legends associated with the Aranmula mirror, one version reported by the author was that the craftspeople migrated from Sankarankoil in Tamil Nadu (with *kannadi* being the Tamil word for mirror as well). A widow Parvati Ammal is said to have dreamt up the shining alloy which pleased the Raja of Aranmula. The spectacularly carved wooden tiered-roofed Aranmula Parthasarathy temple is dedicated to the presiding deity of the Lord Krishna and overlooks the Pampa river. The alluvial clays from the banks of the Pampa provided the moulding materials for the traditional crafts for centuries. Although further studies are needed to explore the antiquity, analysed copper alloy mirrors from around the world or the Indian subcontinent have usually been of a lower tin content or with lead added. However, it is intriguing that a mirror uncovered by Breeks in the 19th century from the Nilgiri Iron Age cairns from the Udhagamandalam region was found to be of 30% tin bronze, not dissimilar to the specular bronze. Hence more investigations need to be done into earlier examples of mirrors to establish the correlations and continuities in antiquity.

Investigations on an antique mirror of about the 17th-18th century was made by the author, with the Gandaberundam motif (Fig. 3) of the Travancore rulers of Southern Kerala, within whose domain Aranmula fell. Interestingly, the micro-structural investigations indicated that the mirror's composition consisted almost entirely of pure crystals of delta phase, practically consisting of pure delta intermetallic compound of 32.6% tin (Fig. 4). This stands testimony to the skill of the craftspeople in making mirrors of pure delta bronze, as an ideal mirror material.

Figure 3: Old mirror from Kerala with insignia of Travancore with gandaberundam

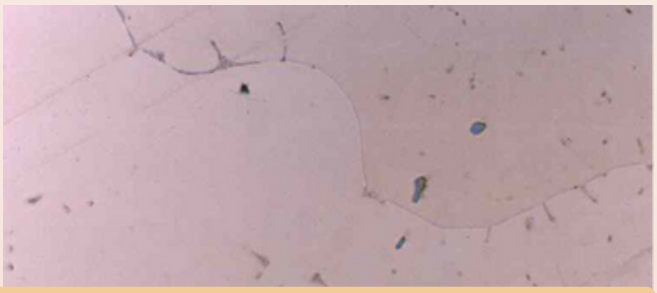

Figure 4: Micro-structure of above old mirror showing that it consists of pure whitish/silvery delta phase compound crystals (32.6% tin in copper) and scarcely any bluish alpha plus delta eutectoid phase at the grain boundaries

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