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Micro-Thin Lens/Bifocal Contact Lens Final Report CRADA No. TC-0331-92-1B

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Disclaimer

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

Micro-Thin Lens/Bifocal Contact Lens

Final Report
CRADA No. TC-0331-92-1B
Date Technical Work Ended: December 31, 1999

Date: June 5, 2001 Revision: 4

A. Parties

The Parties to this CRADA are The Regents of the University of California as operators of the Lawrence Livermore National Laboratory (LLNL) and CIBA Vision Corporation. Initially Chiron Vision of Claremont, CA was another partner in this CRADA, but dropped out within the first six months before completing any work. Chiron Vision was acquired by Bausch and Lomb in early 1998.

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B. Project Scope

The purpose of this project was to develop medical devices for human vision correction based upon thin lens technologies.

LLNL and CIBA Vision were to jointly determine the feasibility of the Micro-Thin Lens (MTL) for human vision correction. They wanted to:

1) Design and fabricate prototype optical designs for thin, color corrected, efficient bifocal (and monofocal) Micro-Thin Lenses for contacts and "in-lay" lenses

2) Identify and evaluate appropriate biocompatible material candidates

3) Develop manufacturing and fabrication technologies

The project was divided into three, one-year phases.

Phase 1 (months 1-12)

1. Defined technical specifications (consistent with regulatory requirements) for bifocal lenses (and monofocal)
2. Designed bifocal (and monofocal) lenses
3. Developed lens fabrication processes
4. Identified a list of candidate materials

Phase 2 (months 13-24)

1. Fabricated and delivered bifocal (and monofocal) lenses meeting the specifications defined in Phase 1.
2. Performed optical evaluation of the lenses, as well as preliminary clinical tests on the bifocal (and monofocal) lenses.
3. Tested stability of biocompatability and materials
4. Developed a cost effective manufacturing process
5. Evaluated manufacturing processes

Phase 3 (months 25-36)

1. Demonstrated a manufacturing process for the mass production of the lenses
2. Designed and identified materials for bifocal (and monofocal) "on-lay" lenses which incorporate the knowledge base developed during Phase 1 and 2

Deliverables

The original deliverables were:

Phase 1 (months 1-12)

- Develop specifications for bifocal (and monofocal) lenses (LLNL/CIBA)
- Design bifocal (and monofocal) lenses meeting these specifications (LLNL)
- Identify candidate materials for the lens (CIBA)
- Identify candidate fabrication processes for a prototype lens (LLNL/CIBA)
- Evaluate the applicability of the technology developed for bifocal lenses to monofocal lens designs (CIBA/LLNL)

Phase 2 (months 13-24)

- Deliver a prototype bifocal lens (LLNL)
- Evaluate lens performance and assemble data on:
    - Optical (bench) performance analysis (LLNL)
    - Materials biocompatability performance analysis (CIBA)
    - Materials stability performance analysis (CIBA)
    - Clinical and regulatory tests (CIBA)
- Develop a clear engineering path for a cost-effective manufacturing process for lens production (LLNL/CIBA)
- Evaluate the applicability and transfer the knowledge base developed during Phases 1 and 2 to monofocal lens designs (LLNL/CIBA)

Phase 3 (months 25-36)

- Demonstrate the manufacturing process (LLNL/CIBA)
- Design bifocal "on-lay" lenses (LLNL)
- Evaluate candidate materials for "on-lay" lenses (CIBA)
- Evaluate the applicability and transfer the knowledge base developed during Phases 1, 2 and 3 to monofocal lens designs (LLNL/CIBA)

Amendments

There were three amendments to this CRADA. **Amendment One** and **Amendment Three** added additional funds-in to complete the existing tasks. Amendment Three also extended the CRADA to December 31, 1999. **Amendment Two** revised the scope of work and extended the term of the CRADA.

In the first two years of the CRADA, LLNL and CIBA Vision explored ideas for presbyopic vision correction. New Contacts that Selectively Tilt (NECST) was one of the most promising ideas for a major breakthrough toward realizing a new medical device for the human vision correction market. NECST is a photopolymer-based contact lens with an integral volume phase diffraction grating (HOE) that adds additional optical power to the contact lens base optical power when translated slightly on the eye.

The unfinished work contemplated under the original Scope of Work was replaced by a follow-on two-year project.

The new two-year follow-on project encompassed the development of bifocal contact lens prototypes that could be clinically tested to evaluate and optimize the overall NECST design and the development of a process (and associated hardware) to produce an adequate number of prototype lenses. The project was divided into two one-year phases with technical recommendations made at the end of each phase as to the viability of the project.

The first year focused on the refinement of the NECST design and fabrication. The second year focused on its optimization of the NECST.

The principal goal for the first year was to develop and deliver prototype lenses suitable for on-eye testing. The strategy was to separate the LLNL task of recording the bifocal contact lens and the CIBA task of making the translating contact lens. LLNL recorded HOEs in non-translating contact lenses. In one set of lenses, the diffractive component was positioned on the visual axis, and, in a second set of lenses, the diffractive component was positioned off the visual axis. In both cases the diffractive component added +2 Diopters. An ancillary goal was to develop and document a laboratory-scale process for producing the prototype contact lenses.

The principal goal for the second year was the integration of an optimized HOE with the carrier technology developed by CIBA to produce a NECST prototype. An ancillary goal was to refine the process for producing and characterizing the NECST devices.

The following task and deliverables were completed under Amendment Three:

1. Evaluated the HOE optical noise caused by diffraction of off-axis light. Based on optical modeling, determine which image metrics best characterize this noise term. Predicted image quality in various illumination settings. Investigated possible methods for elimination or minimization of noise with a concerted effort to arrive at a proposed solution by 12/21/98.

2. Determined parameters that control color banding and optimize design to minimize this effect. Characterized optical impact for both near and distant vision positions of the lens.

3. Collaborated with CIBA to define the desired photopolymer optical properties. Established protocols for evaluating photopolymer products developed by CIBA.

4. Developed a scalable process for producing HOE bifocal contact lenses. Provided consulting expertise to implement the process for mass manufacturing.

5. Delivered best-available HOE bifocal contact lenses for clinical testing.

C. Technical Accomplishments

The following statement was extracted from the 11/30/99 letter from CIBA:

> "The base concept had been to utilize a photopolymer in which a 2-layer VHOE could be written, creating an additional optical power in the lens that would become manifest upon translation of the eye. Several technical

hurdles were identified that had to be overcome to realize this objective. Fundamental among these is the minimization of color rendering error and noise necessary to achieve acceptable chromatic free imagery. While the other tasks have essentially been achieved, the objectives led by LLNL of creating an achromatic HOE remains largely unfulfilled, with no viable solution in sight.

Due to the high risk associated with continued funding for this research, CIBA Vision elected not to extend the CRADA. A meeting was arranged to discuss allocation of Intellectual Property and to finalize a License Agreement."

D. Expected Economic Impact

D.1 Specific Benefits

Human vision correction is a very competitive industry and the first insertion of a new technology can often result in a dramatic competitive edge. The application of MTL's to presbyopia, myopia and hyperopia could dramatically impact the health care industry and reduce medical costs.

The refinement of the MTL technology embodies a new concept in the correction of chromatic aberrations in diffractive optics. If the MTL technology can be fully developed, LLNL will posses an important new technology that can be deployed in the design of compact optical systems. The potential benefits to the defense program are in two areas:

1. Advanced optical instruments for the stockpile stewardship program
2. Heads-up displays

E. Partner Contribution

The CRADA partner, CIBA Vision, was the technical driver of the project. While LLNL had unique expertise in thin, diffractive lens technology, CIBA provided all the opthalmic expertise. They defined and evaluated the commercial market and specifications for a viable bifocal contact lens. They conducted a number of clinical experiments with human subjects and collected existing data to characterize the needed range of corrections for various market segments. CIBA evaluated various competing products. Monthly technical and business meetings were held at CIBA in Duluth, Georgia. LLNL staff often traveled to Duluth to attend these meetings. The meeting attendance was around ten technical staff. Larger, annual reviews were held off-site.

CIBA was the principal partner in the generation of the basic idea for the NECST contact lens. CIBA took ownership for delivery of a translating contact lens carrier for the eye. A number of designs were presented, prototyped and evaluated in the clinic.

CIBA was responsible for developing and providing biocompatible polymers for the contact lenses. They sent various materials to LLNL for evaluation. In the end, an existing material polymer used by CIBA for contacts proved to be the most promising.

The final goal of the CRADA project was to demonstrate the NECST concept in human subjects. This goal was not achieved. LLNL was unable to provide a diffractive lens that had the dual properties of high diffraction efficiency and low noise. CIBA was unable to provide a translating carrier meeting the required specifications.

The NECST concept is protected by a pending United States patent and future work may make the concept competitive.

F. Documents/Reference List

Reports
None

Copyright Activity
None

Subject Inventions

IL-10080: Patent Pending

Background Intellectual Property

The following three pieces of BIP were disclosed under the original CRADA:

IL-8748, IL-9587, U.S. Patent 5,257,132

Under Amendment Two, the previous BIP list was deleted and replaced with the following three pieces of BIP:

IL-10080, IL-9493B, U.S. Patent 5,257,132

No BIP was licensed.

G. Acknowledgement

Participant's signature of the final report indicates the following:

1) The Participant has reviewed the final report and concurs with the statements made therein.
2) The Participant agrees that any modifications or changes from the initial proposal were discussed and agreed to during the term of the project.
3) The Participant certifies that all reports either completed or in process are listed and all subject inventions and the associated intellectual property protection measures generated by his/her respective company and attributable to the project have been disclosed and included in Section E or are included on a list attached to this report.
4) The Participant certifies that if tangible personal property was exchanged during the agreement, all has either been returned to the initial custodian or transferred permanently.
5) The Participant certifies that proprietary information has been returned or destroyed by LLNL.

13JUN01

Rafael Andino — Date
CIBA Vision Corporation

6/25/01

Sheila Vaidya — Date
Lawrence Livermore National Laboratory

Attachment I – Final Abstract

Micro-Thin Lens/Bifocal Contact Lens

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E. Dates of Project

March 6, 1996 – December 31, 1999